DOCUMENT RESUME

ED 419 672 SE 061 376

AUTHOR	Fortner, Rosanne W., Ed.
TITLE	Great Lakes Shipping. Earth Systems - Education Activities for Great Lakes Schools (ES-EAGLS).
INSTITUTION	Ohio State Univ., Columbus. Ohio Sea Grant Program.
REPORT NO	EP-084
PUB DATE	1997-00-00
NOTE	93p.; For other documents in the series, see SE 061 374-378.
CONTRACT	NA46RG0482
AVAILABLE FROM	Ohio Sea Grant Publications, The Ohio State University, 1314 Kinnear Road, Columbus, OH 43212-1194; phone: 614-292-8949.
PUB TYPE	Guides - Classroom - Learner (051) -- Guides - Classroom - Teacher (052)
EDRS PRICE	MF01/PC04 Plus Postage.
DESCRIPTORS	Cooperative Learning; Curriculum Enrichment; Economics; Instructional Materials; Intermediate Grades; Learning Activities; Middle Schools; *Navigation; Science Education; Scientific Literacy; Secondary Education; Social Studies; *Transportation; *Water Resources
IDENTIFIERS	Canals; *Great Lakes; National Science Education Standards; Project 2061 (AAAS); *Shipping Industry; Ships

ABSTRACT

This activity book is part of a series designed to take a concept or idea from the existing school curriculum and develop it in the context of the Great Lakes using teaching approaches and materials appropriate for students in middle and high school. The theme of this book is Great Lakes shipping. Students learn about the connections between the United States and the rest of the world via shipping through the Great Lakes, economics of transportation, shipwrecks in the Great Lakes including the Edmund Fitzgerald, and early shipping activity within Ohio via canals. Activities are divided into several subjects: (1) Great Lakes Shipping; (2) World Connections; (3) Language; (4) Great Lakes Triangle; and (5) Canals. The activities are characterized by subject matter compatibility with existing curriculum topics. Several kinds of connections have been designed to assist teachers in finding the place where the new materials fit and also the justification for fitting them. The connections include a Framework of Seven Understandings developed by science teachers, science educators, and scientists to represent fundamental desired results of science education. Each activity in this book addresses a number of these Understandings and two or more Earth subsystems. Connections are also made to the National Science Education Standards and the Benchmarks for Science Literacy. (PVD)

GREAT LAKES SHIPPING

ES—EAGLS

Earth Systems — Education Activities for Great Lakes Schools

The Ohio Sea Grant College Program is one of 29 state programs that works to increase understanding and wise use of the nation's ocean and Great Lakes resources. Projects are conducted in partnership with government, academia, industry, and the general public. Sea Grant fulfills its mission by promoting education excellence, responsive research and training, and broad, prompt dissemination of knowledge and technical information.

Earth Systems - Education Activities for Great Lakes Schools (ES-EAGLS)

This series of publications was produced as a result of Ohio Sea Grant Education Program's project "Cooperative Curriculum Enhancement and Teacher Education for the Great Lakes" funded by Ohio Sea Grant under grant NA46RG0482, project E/CMD-3, with support from The Ohio State University and cooperating schools.

ES-EAGLS are designed to take a concept or idea from the existing school curriculum and develop it in a Great Lakes context appropriate for students in middle and high school.

Education and Series Coordinator

Rosanne W. Fortner

Series Editors

Land & Water Interactions in the Great Lakes EP-082
Amy L. Sheaffer

Great Lakes Climate & Water Movement EP-083
Heidi Miller and Amy L. Sheaffer

Great Lakes Shipping EP-084
Rosanne W. Fortner

Life in the Great Lakes EP-085
Amy L. Sheaffer

Great Lakes Environmental Issues EP-086
Amy L. Sheaffer

Additional assistance was provided by
the Ohio Sea Grant Communications Program by
Maran Hilgendorf, coordination;
Cindy Hayter and Jill Mank, production; and
Jean Johnson, copy editing.
Cover illustrations by Matt Trefz, Ohio State University Extension.

Additional publications produced by Ohio Sea Grant include other curriculum activities, education publications, fact sheets, guides, and videos on subjects such as global change and marine careers. For a complete list, request a publications brochure from Ohio Sea Grant at the address on the left.

Sea Grant
Ohio Sea Grant College Program
Jeffrey M. Reutter
Director

Ohio Sea Grant Publications
The Ohio State University
1314 Kinnear Road
Columbus, OH 43212-1194
614/292-8949
Fax 614/292-4364

http://www-ohiosg.osc.edu/
OhioSeagrant

ES - EAGLS

Earth Systems - Education Activities for Great Lakes Schools

Results of studies of student knowledge about the oceans and Great Lakes environments indicate a need for greater awareness and a greater understanding of the impact they have upon our lives. Earth Systems - Education Activities for Great Lakes Schools are designed to take a concept or idea from the existing school curriculum and develop it in a Great Lakes context, using teaching approaches and materials appropriate for students in middle and high school.

The activities are characterized by subject matter compatibility with existing curriculum topics; short activity time lasting one to three classes; minimal preparation time; minimal equipment needs; standard page size for easy duplication; suggested extension activities for further information or creative expression; teachability demonstrated by use in middle school classrooms; and content accuracy assured by critical reviewers.

Included with the activities are some suggestions about possible ways to use the activities in cooperative learning situations and how lessons can be structured according to the learning cycle.

This is one of a series of subject area activity books being published. The subject of this book is Great Lakes shipping. Other subject areas available are land and water interactions, climate and water movement, the Great Lakes ecosystem, and Great Lakes environmental issues. For a more detailed listing of shipping activities, see the matrix on page 7. Most of the activities in this book were modified from Oceanic Education Activities for Great Lakes Schools (OEAGLS), developed by the Ohio Sea Grant Education Program and revised from 1985 to 1991. All ES-EAGLS are listed inside the back cover.

Great Lakes Shipping

INTRODUCTION

ACTIVITIES

Great Lakes Shipping

World Connections

Language

Great Lakes Triangle

Canals

APPENDIX

Using *ES-EAGLS Great Lakes Shipping*

An accompanying matrix matches activities to the Earth Systems Understandings (ESUs), and the Earth subsystems directly addressed (hydrosphere, lithosphere, cryosphere, biosphere, atmosphere) demonstrate the range of instructional opportunities available for the classroom.

The principles that guided development of the activities should also direct their classroom use:

- Potential for collaborative learning and group decision making.
- Use of historical and descriptive as well as experimental data.
- Integration of science disciplines in a social context.

It is recommended that the format for the activities be retained when they are used in the classroom. Some short activities are designed for introduction to topics or for awareness. Longer activities focus attention for extended work and are designed to build understanding, synthesis, application, and evaluation skills. The extent and focus of the activities will help teachers decide which are useful in cooperative groups and which are best for use by the class as a whole.

1. <u>Each activity is a question to be explored</u>. Far too many classroom activities are done for the sake of activity alone. If an important and relevant question is the guide for learning, there is greater focus and a readily apparent reason for doing the activity. Be sure to call students' attention to the question driving the exploration and encourage creative approaches to problem solving.

2. <u>Most activities are addressed to the student for direct use</u>. Additional notes and answers for teacher use are found in narrow columns on each page so they can be concealed if the page is to be given to students.

3. <u>Activities do not stand alone</u>. They should be linked, before and after, to other curriculum topics and information resources such as the Internet. The best questions are those that lead to more questions!

Cooperative Learning Possibilities

There are many ways to organize the activities with cooperative learning strategies, and none of them is the "right way." You are encouraged to modify strategies to make the activities work in your setting. Some possible strategies follow.

Groups

Divide the class into three or four groups, with each group responsible for certain tasks that will contribute to class learning. Assign each group member a job or task appropriate to the lesson. He or she is then responsible to the group for doing this job. Jobs can be combined, and they should be rotated between group members periodically. Some possible job descriptions are:

Facilitator	Develops a plan with the group so that the group will finish within the time limit.
Recorder	Records plan, answers, and conclusions as appropriate.
Reader	Reads instructions and background material to group.
Artist	Sketches diagrams, posters, and charts as appropriate.
Checker	Checks to make sure the group is following instructions and the plan.
Speaker	Shares group progress report with class.
Materials Expert	Gets lab materials and makes sure things are cleaned up and returned.

JIGSAW

Divide the class into groups of four students each. These are the base groups. Then divide the class differently into four expert groups. One person from each base group will be in each of the four expert groups. (You will need to adjust the numbers of groups depending on your class size.) Each student should be in two groups. Instead of having every student doing all activities, assign each expert group a different activity or task for which it becomes the expert. Then have students meet in their base group and share what was done in the expert group and what was learned. Or have the expert groups do their activities and then rotate the base groups through the activities with the "expert" members leading the base groups through the activity.

STUDENT TEAMS ACHIEVEMENT DIVISIONS

After some type of class presentation such as a lecture, video, or textbook reading, students are divided into teams. Students on the teams work together to make sure that all members of the team understand the material of the presentation. The students then take a quiz individually. Students have a minimum desired score, and the team works to get a high team improvement score (points above the minimum desired score). For more information about this strategy, read *Using Team Learning* by Robert Slavin (Baltimore: The Johns Hopkins Team Learning Project, 1986).

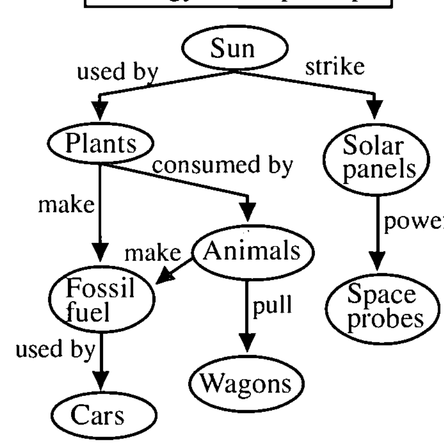
CO-OP CO-OP

This strategy is very student-directed. Students are in teams based on shared interest. The teams subdivide their topic, and each student is responsible to research his or her own subtopic. Students then share what they have learned about the subtopic with their whole team. The teams then prepare a presentation for the entire class, and they are encouraged to include the class in the presentation in some way. *Cooperative Learning: Resources for Teachers* by Spencer Kagan (Riverside, CA: University of California, 1985) provides more information about this strategy.

ASSESSMENT STRATEGY: CONCEPT MAPPING

Concept mapping is one way of having students show visually their understanding of concepts and the concepts' relationships to each other. This can be done as a pre-assessment or a post-assessment or both to see the change in a student's understanding. A brief strategy for use of concept mapping would be to brainstorm a list of terms that students know about a topic. Add terms that you want to make sure are included. Have students start with the topic at the top or center of a sheet of paper, and then, using arrows and labels, students place the brainstormed terms on the map, showing how they are related. See the example of a student's preliminary energy concept map.

Energy Concept Map



There are many other ways of assessing student achievement, including performance assessment, portfolios, and grading rubrics. To learn more about these strategies you might read:

Aronson, J. 1978. *The Jigsaw Classroom*. Beverly Hills: Sage.

Hassard, Jack. 1990. Cooperating Classroom. *Science Scope*. March, p. 36-45.

Johnson, D.W., R.T. Johnson and E.J. Holubec. 1986. *Circles of Learning: Cooperation in the Classroom*. Edina, MN: Interaction Book Company.

Mayer, V.J. and R.W. Fortner, Eds. 1995. *Science Is a Study of Earth - A Resource Guide for Science Curriculum Restructure*. Columbus, OH: Earth Systems Education Program,The Ohio State University.

Special Supplement on Assessment. March, 1992. *Science Scope*. This issue contains articles on performance assessment, portfolios, group assessment, concept mapping, and rubrics.

Example Cooperative Lessons

Note: Complete information on materials and methods can be found in the activities listed.

Example I: Students will be able to describe the current status of Great Lakes shipping, its economic and environmental importance, and its early links to canals.

Engagement

1. Help students begin to construct their learning about the topic. Ask questions such as whether any students have seen boats carrying cargo on the water, whether any have been to or seen Great Lakes ports, and what kinds of cargo are visible at ports. Get class perceptions of how fast boats go compared to trains and trucks, and how much pollution boats create.

2. Conduct the Project WET activity titled "Water Crossings," and modify the discussion to be based on Great Lakes boats.

3. Topic Preparation: Assign the reading of Chapters 8 and 9 of *The Great Lake Erie* (Fortner and Mayer, 1993) as homework for the next day. Discuss readings as a class or in groups.

Exploration

Jigsaw: Divide the class into three expert groups. A leader selected within each group will have the complete pages of the activities, including teacher notes. Other expert group members will have the student worksheets and other instructions from the activities. Assign each expert group different tasks as follows:

Task 1. Shipping within the Great Lakes. The group leader conducts the activity "What products are carried on the Great Lakes?" Then the group divides into two research teams to investigate "What is the most economical form of transport?" and "Which transportation method uses the least energy?" The leader conducts a discussion based on the Review Questions for all three activities, and the team decides which information to share with the base groups (**Evaluation**).

Task 2. World shipping. The group leader conducts a "dry lab" of "How do ships go from one lake to another?" Then the group divides into two research teams to investigate "Where go the boats?" Assign one team to Procedure A-E and the other to Questions 7-14. When all the responsibilities have been completed, team members share their information and be sure they can answer questions 1-15. The leader leads a discussion of the Review Questions that follow each activity (**Evaluation**). The group decides how to present its information to base groups.

Task 3. Canal days in the Great Lakes. The experts divide into two research teams to investigate "How were the early canal routes determined?" and "How did the canals affect Ohio?" The teams combine their information and answer the review Questions for each of the activities (**Evaluation**). The group decides how to present its information to base groups.

Base groups meet and share what the experts have learned, and how the questions might be answered. Be certain that the objectives of each activity can be met by students in the base groups.

Elaboration

1. As a class, view Part 1 of the videotape series on "Ohio's Canal Era," which gives visual interpretations to the activities that have just been completed. It is an historical background of canals in general.

2. Since Ohio was not unique in its attempts to use canals to increase market access, examine the other canal systems through their addresses on the Internet, as identified in the activity. In what ways were the states' efforts similar? How were they different?

Evaluation

Assign a portfolio element in which students add their knowledge from the jigsaw to that of the videotape and readings. An example might be:

It is late May of this year. Assume you represent a company that wishes to ship 15,000 metric tons of goods from Hamilton Harbor, on Lake Ontario, to Chicago, and have them arrive in September. Compare the options you have for shipping, and make a decision on which transportation method to use. Then develop a presentation to the Board of Directors that justifies your decision. Be sure you address environmental as well as economic considerations, and take into account the season, traffic levels, and your choice of ship to use (U.S. flag or other).

Example II: Students will investigate the possible causes of the sinking of the *Edmund Fitzgerald*, as an example of how interdisciplinary science mysteries are approached by scientists.

Engagement

With the entire class, conduct the activity titled "What is the Great Lakes Triangle?" Discuss the implications of these unsolved mysteries, and decide how to take them on as scientists.

Exploration

Jigsaw: Assign expert groups to investigate the three hypotheses as presented in "How can disappearances within the Triangle be explained?" **Evaluation** occurs as the experts decide how to answer their questions.

Elaboration and Evaluation

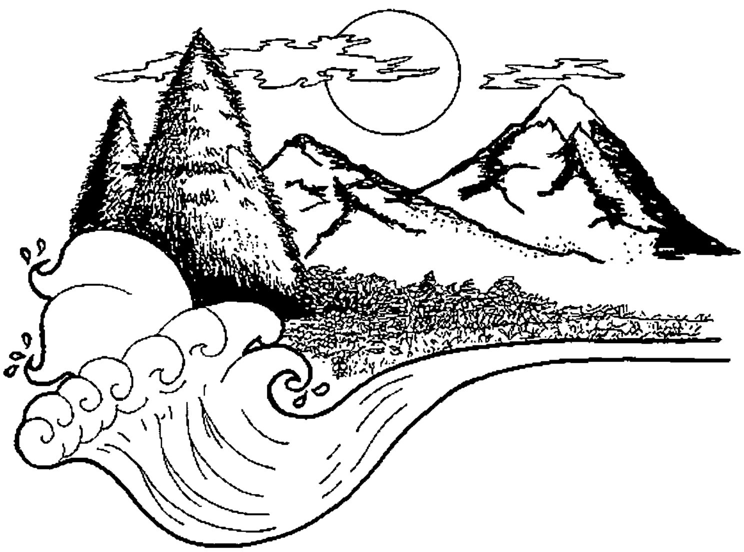
As individuals, students do creative writing in "What happened aboard the *Edmund Fitzgerald*?" A portfolio element based on the additional news articles could also be devised to assess scientific approaches.

Making Connections

There is always a danger in producing curriculum materials designed for infusion. How can we facilitate getting new material into the existing flow of classroom subject matter? In this project we have designed several kinds of connections to assist teachers in finding not only the place where the new materials fit, but also the justification for fitting them and the ancillary resources that can contribute to their effectiveness. The connections we see are demonstrated here and in the charts on the following pages.

Earth Systems Education

http://www.ag.ohio-state.edu/~earthsys

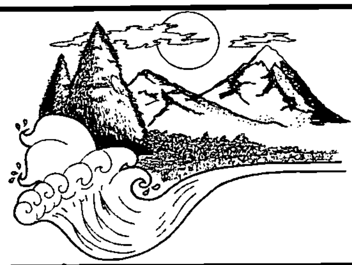


Earth Systems Education is a program of curriculum restructure in which teachers take responsibility for critical evaluation of their science curriculum, including content, classroom processes, learner outcomes, and assessment, and strive to make changes that create a curriculum more responsive to human needs and future quality of life. Earth systems education is based on integration of traditional science disciplines for a more comprehensive understanding of the interactions of Earth subsystems: the hydrosphere, lithosphere, atmosphere, biosphere, and cryosphere.

Efforts are guided by a Framework of seven Understandings (p. 7 and Appendix) developed by science teachers, science educators, and scientists to represent fundamental desired results of all of science education. Each activity in this set addresses a number of the Understandings and two or more Earth subsystems, and includes suggestions for extending learning.

The process of curriculum change is assisted by scientists and science educators through development of materials such as these. Additional materials available for Earth Systems Education include a resource guide for science curriculum restructure using Earth as a focus. The guide, titled *Science Is a Study of Earth,* includes research background, teacher experiences, and samples of activities useful at elementary, middle and high school levels. Another volume of activities is designed to help secondary science teachers address the complex issues of global change. *Activities for the Changing Earth System (ACES)* includes 20 interdisciplinary activities. These publications are available from the Earth Systems Education Program, c/o OSU School of Natural Resources, 2021 Coffey Road, Columbus, OH 43210.

Ohio Sea Grant has also produced regional information and activities about global change. *Great Lakes Instructional Materials for the Changing Earth System (GLIMCES)* includes classroom activities for secondary science, based on *Global Change in the Great Lakes Scenarios.* These can be ordered ($9.00 for both) from Ohio Sea Grant, 1314 Kinnear Road, Columbus, OH 43212-1194.



SHIPPING in the GREAT LAKES REGION

pg #	Activities	Earth Systems Understandings							Earth Subsystems				
		Beauty & Value	Stewardship	Scientific Process	Interactions	Change Through Time	Earth As Subsystem	Careers & Hobbies	Hydrosphere	Lithosphere	Cryosphere	Atmosphere	Biosphere
pg #	Activities	1	2	3	4	5	6	7	1	2	3	4	5
13	What products are carried on the Great Lakes?		X	X				X	X				X
17	What is the most economical form of transportation?		X	X				X	X				X
21	Which transportation method uses the least energy?		X	X				X	X				X
25	Where go the boats?		X	X	X			X	X		X		X
33	How do ships get from one lake to another?		X	X	X	X		X	X				X
39	How have ships and sailing influenced our language?	X						X					
43	What is the Great Lakes Triangle?	X	X	X	X	X	X	X	X				X
47	How can disappearances in the Triangle be explained?			X	X	X		X	X	X		X	X
71	What happened aboard the *Edmund Fitzgerald*?	X											
75	How were early canal routes determined?		X	X		X		X	X				
79	How did the canals affect Ohio?		X	X	X			X	X				X

FRAMEWORK FOR EARTH SYSTEMS EDUCATION*

Understanding #1. Earth is unique, a planet of rare beauty and great value.

Understanding #2. Human activities, collective and individual, conscious and inadvertent, affect Earth systems.

Understanding #3. The development of scientific thinking and technology increases our ability to understand and utilize Earth and space.

Understanding #4. The Earth system is composed of the interacting subsystems of water, rock, ice, air, and life.

Understanding #5. Earth is more than 4 billion years old, and its subsystems are continually evolving.

Understanding #6. Earth is a small subsystem of a Solar system within the vast and ancient universe.

Understanding #7. There are many people with careers and interests that involve study of Earth's origin, processes, and evolution.

* complete Framework on page 85

National Science Education Standards

The activities in *Earth Systems-EAGLS* have connections to other national developments in science education. Numerous efforts have been underway in the 1990s to restructure science education in response to growing concerns that the historic "layer cake" (discipline-ordered) approach to science lacks relevance to students, prepares them poorly in life skills that demand science literacy, leaves U.S. students lagging on standardized international tests of science knowledge, and ignores or perhaps even perpetuates naive conceptions in science. The primary efforts to change these patterns have emerged from and been supported by national organizations in science and education.

The National Science Education Standards represent the National Academy of Science's attempt to develop guidelines for science curriculum restructure and systemic change in K-12 education. The National Standards include science content standards that express need for integration of disciplines, fewer topics in greater depth, and articulation across grade levels. They do more by providing guidelines for restructuring the teaching of science, the environment for science in schools, and assessment of science learning. The Standards emerged in 1995 as the most comprehensive and perhaps most esteemed of the restructure guidelines.

The matrix found in the side columns demonstrates the connections of *Earth Systems - Education Activities for Great Lakes Schools* to many of the National Science Education Standards. Standards preceded by an asterisk (*) are specifically addressed in this activity set.

Content standards, Grades 5-8

Science as inquiry
* Abilities related to scientific inquiry
* Understanding about scientific inquiry

Physical science
Properties and changes of properties in matter
* Motions and forces
Transfer of energy

Life science
Populations and ecosystems
Diversity and adaptations of organisms

Earth and space science
Structure of the Earth system
Earth's history

Science and technology
* Understanding about science and technology

Science in personal and social perspectives
* Populations, resources, and environments
* Natural hazards
* Risks and benefits
* Science and technology in society

History and nature of science
* Science as a human endeavor
* Nature of science

Unifying concepts and processes
Order and organization
* Evidence, models, and explanation
Change, constancy, and measurement
Evolution and equilibrium
Form and function

Benchmarks for Science Literacy

Project 2061 is supported by the American Association for the Advancement of Science (AAAS). Through its book *Science for All Americans*, this project identified science concepts that every high school graduate in the United States should know. Major contributions of this effort include the idea that "less is more," or that a curriculum dealing with fewer concepts in greater detail is preferred over the traditional vocabulary-laden mini-college courses common in U.S. secondary schools. Follow-up work through selected school districts produced several models for implementing the curriculum changes implied by 2061, and has resulted in a set of Benchmarks for designing the course sequences and gauging the progress of students in science through their school careers.

Many of the Benchmarks are addressed through activities in this volume. They are too numerous to list here in their entirety, but the following Benchmarks are among those applicable to the activities.

Examples for grades 6-8 include:

- Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigtions usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.
- Freshwater, limited in supply, is essential for life and also for most industrial processes. Rivers, lakes, and ground water can be depleted or polluted, becoming unavailable or unsuitable for life.
- Technology, especially in transportation and communication, is increasingly important in spreading ideas, values, and behavior patterns within a society and among different societies. New technology can change cultural values and social behavior.

For grades 9-12, these materials address:

- Human beings are part of the Earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.
- The size and growth rate of the human population in any location is affected by economic, political, religious, technological, and environmental factors. Some of these factors, in turn, are influenced by the size and rate of growth of the population.
- In designing a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced, and disposed of and who will sell, operate and take care of it. The costs associated with these functions may introduce yet more constraints on the design.

Content standards, Grades 9-12

Science as inquiry
* Abilities related to scientific inquiry
* Understanding about scientific inquiry

Physical science
Chemical reactions
* Forces and motions
Conservation of energy
Interactions of energy and matter

Life science
Biological evolution
The interdependence of organisms

Earth and space science
* Energy in the Earth system
Origin and evolution of the Earth system

Science and technology
* Understanding about science and technology

Science in personal and social perspectives
Natural resources
* Environmental quality
* Natural and human-induced hazards
* Science and technology in local, national, and global challenges

History and nature of science
* Science as a human endeavor
* Nature of scientific knowledge
* Historical perspectives

Unifying concepts and processes
Order and organization
* Evidence, models, and explanation
Change, constancy, and measurement
Evolution and equilibrium
Form and function

Other Connections

Canadian Atmospheric Environment Service
Environment Canada, 4905 Dufferin Street, Downsview, Ontario, Canada M3H 5T4

Cooperative Institute for Limnology and Ecosystems Research (CILER)
CILER's research focuses on climate and large-lake dynamics, coastal and near shore processes, and large lake ecosystem structure and function. This and other information can be found on the World Wide Web. The institute is comprised of the University of Michigan, Michigan State University and GLERL
Address: CILER, University of Michigan, Ann Arbor, MI 48109. http://www.glerl.noaa.gov/ciler/ciler.html

Great Lakes Commission
This is an interstate commission of the eight Great Lakes states established in 1955 to "promote the orderly, integrated and comprehensive development, use and conservation of the water resources of the Great Lakes Basin." Address: The Argus II Building, 400 Fourth St., Ann Arbor, MI 48103
Phone: (313)665-9135; http://www.glc.org

Great Lakes Environmental Research Laboratory (GLERL)
GLERL is the NOAA research laboratory that has been assigned the responsibility of conducting environmental research with an emphasis on the Great Lakes. Some major topics of research are toxins in the Great Lakes, natural hazards, ecosystem interactions, hydrology, and effects related to global climate change.
Address: 2205 Commonwealth Blvd., Ann Arbor, MI 48105. Phone: (313)741-2244
http://www.glerl.noaa.gov/

Great Lakes Information Network (GLIN)
A great place to start exploring the Great Lakes on the Internet. Internet: http://www.great-lakes.net/

International Joint Commission (IJC)– main office:
100 Ouellette Avenue, Windsor, Ontario, Canada N9A 6T3. Phone: (519)256-7821; Detroit Office:
P.O. Box 32869, Detroit, MI 48232. Phone: (313)226-2170. http://www.great-lakes.net:2200/partners/IJC/ijchome.html

Lake Carriers Association
This is a trade organization representing almost all of the U.S.-flag vessels on the Great Lakes. LCA publishes regular updates of shipping traffic and cargo. Address: 614 Superior Ave. 915 W, Rockefeller Bldg., Cleveland, OH 44113-1383. http://ne1.bright.net/lcaships/

National Sea Grant College Program – Great Lakes Network
http://www.mdsg.umd.edu/NSGO/index.html (One web site links all Sea Grant programs.)
Illinois/Indiana Sea Grant Program, 1206 S. Fourth St., 104 Huff Hall, Champaign, IL 61820. Phone: (217)333-1824
Michigan Sea Grant College Program, 2200 Bonisteel Blvd., Ann Arbor, MI 48109. Phone: (313)763-1437
Minnesota Sea Grant College Program, 1518 Cleveland Ave., N., Rm 302, St. Paul, MN 55108. Phone: (612)625-2765
New York Sea Grant Institute, State Univ. of NY, Nassau Hall, Stony Brook, NY 11794-5000. Phone: (516)632-6905
Ohio Sea Grant College Program, 1314 Kinnear Rd., Columbus, OH 43212-1194. (614)292-8949
Wisconsin Sea Grant, 1800 University Ave., Madison, WI 53705-4094. (608)262-0644

NOAA Global Change Education Program
NOAA, U.S. Department of Commerce, 1100 Wayne Ave., Rm. 1210, Silver Spring, MD 20910-5603.
Phone: (301)427-2089. The NOAA Home Page is: http://www.noaa.gov

INTERNET SITES OF GENERAL INTEREST:

http://www.ncdc.noaa.gov – National Climatic Data Center
http://sparky.nce.usace.army.mil – U.S. Army Corps of Engineers, Detroit District
http://www.mdsg.umd.edu/NSGO/index.html - Sea Grant Network
http://www.cciw.ca/glimr/intro.html - Great Lakes Information Management Resource (Canadian)
http://www.noaa.gov/ - NOAA Home Page
http://superior.eng.ohio-state.edu/ - The Great Lakes Forecasting System

PUBLICATIONS AND OTHER MATERIALS:

Barry, J.P. 1981. *Wrecks and rescues of the Great Lakes.* La Jolla, CA: Howell-North Books.

Fortner, R.W. and V.J. Mayer. 1993. *The Great Lake Erie. A Reference Text for Educators and Communicators.* Columbus: Ohio Sea Grant. This is the source of information used in most of the ES-EAGLS activities. Chapters are written by experts in Great Lakes topics, and readings from the book can serve as the content base for additional instruction.

The Great Lakes. An environmental atlas and resource book. 1995. Jointly produced by the Government of Canada and U.S. EPA, 3rd edition. Copies available from Great Lakes National Program Office, U.S. EPA, 77 W. Jackson Blvd., Chicago, IL 60604.

The Great Lakes Forecasting System, Department of Civil Engineering, The Ohio State University, with support from GLERL, NOAA. This online system makes predictions of physical variables of the Great Lakes and gives maps of existing conditions on Lake Erie, updated every six hours.
World Wide Web address – http://superior.eng.ohio-state.edu/

International Station Meteorological Climate Summary Ver 2.0 (CD-Rom,DOS). Federal Climate Complex, Asheville, NC.

LesStrang, J. 1977. *Cargo carriers of the Great Lakes.* Boyne City, MI: Harbor House.

Marshall, J.R., Ed. 1987. *Shipwrecks of Lake Superior.* Duluth, MN: Lake Superior Port Cities, Inc.

Mayer, V.J. and R.W. Fortner, 1995. *Science Is a Study of Earth: A Resource Guide for Science Curriculum Restructure.* Columbus, OH: Earth Systems Education Program, The Ohio State University.

Wolff, J.F., Jr. 1990. *Lake Superior Shipwrecks.* Duluth, MN: Lake Superior Marine Museum Association, Lake Superior Port Cities, Inc.

Arts and Literature of the Great Lakes

Many scientists report that their interest in science was at least in part related to their feelings of wonder at the Earth's beauty. As it is stated in Earth Systems Understanding #1, "The beauty and value of Earth are expressed by and for people of all cultures through literature and the arts." The developers of ES-EAGLS encourage teachers to use art, music, and literature in teaching. Not only does this address diverse learning styles and stimulate creativity, it also helps students find meaning behind what may otherwise appear to be topics irrelevant to their lives.

Much support is available for teachers to include the arts in teaching science. Listed below are some of the resources the authors have found most valuable. Your school's librarian and music teacher may know of other resouces that relate to your specific region or Great Lake. Consult local units of the Great Lakes Historical Society and merchants in resort areas of the lakes as well.

Selected Music Resources

Lee Murdock's Great Lakes folk songs are popular in auditorium programs, private performances, and on cassettes. *Cold Winds* and *Freshwater Highway* are our favorite albums. Depot Recordings, P.O. Box 11, Kaneville, IL 6014. Phone: (708)557-2742

Pat Dailey is a country rock singer from Bay Village, Ohio. His albums are a mix of bar-room humor and serious songs of the Great Lakes. We use his "Great Lakes Song" and others on the *Freshwater* album most often. Albums are available from Olympia Records, P.O. Box 40063, Bay Village, OH 44140

Privateer, a Celtic folk duo from the Chicago area that sings traditional Great Lakes songs and original material related to the lakes. Sextant Music, 6342 W. Belmont, Chicago, Il 60634. Phone: (312)775-1257

Songs of the Ohio-Erie Canal is an album from Folkways that is particularly relevant to the Shipping activities. Folkways Records and Services originate in New York City.

Selected Art Resources

The Canadian McMichael Collection (Government of Ontario, 1983) from the McMichael Galleries in Toronto includes the best collection of the Canadian Group of Seven landscape artists.

Canal days in America. Harry Sinclair Drago. 1972, Bramhall House, New York.

The Canadian Earth. Robert Boulet. 1982, Cerebrus/Prentice Hall.

Scenes and Songs of the Ohio-Erie Canal. Columbus: The Ohio Historical Society. Pictures and descriptions of the canals, and several songs sung on the canal boats.

Poetry

Hangdog Reef. Poems Sailing the Great Lakes. This is the only volume we have found specific to Great Lakes topics. Please let us know if you find others!

What products are carried on the Great Lakes?

Have you ever seen a cargo carrier on the Great Lakes? Did you wonder where it was coming from? Where it was going? What it was carrying? The Great Lakes are very important routes for the transportation of freight. What advantages do they have over railroads and trucks? This investigation will help you to answer some of these questions.

In this activity you will look at some of the major products that are transported across the Lakes. You will locate possible routes for transporting these products.

OBJECTIVES

When you have completed this set of activities you should be able to:

- Describe and give examples of some of the major products transported on the Great Lakes.
- Use the scale of a map in determining distances between points.

Source

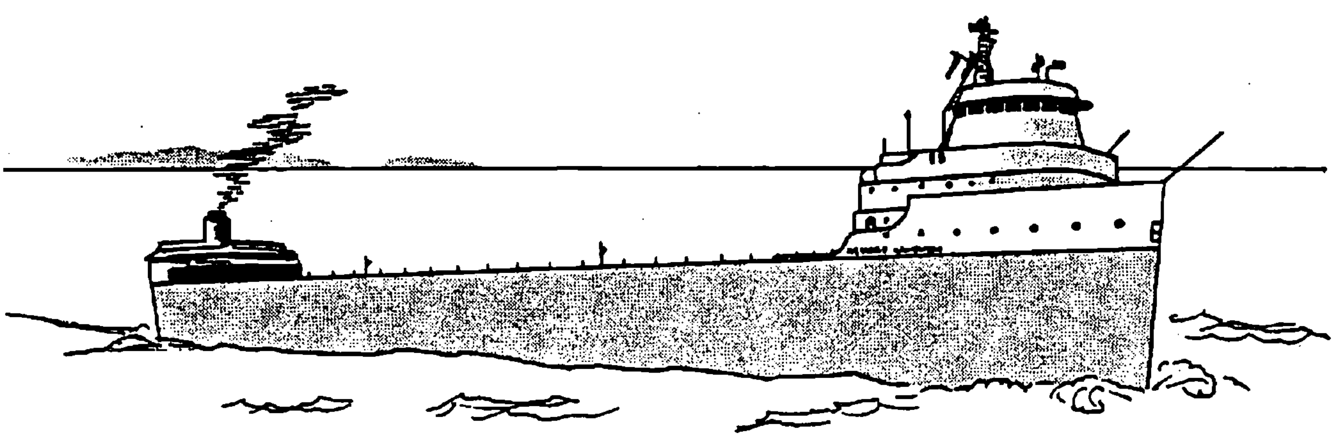
OEAGLS EP-13. *Shipping on the Great Lakes,* Activity A, by Keith N. Schlarb and Victor J. Mayer.

Earth Systems Understandings

This activity focuses on ESU 3 (science processes and data).

Materials

String to use in measuring distances.



A Great Lakes bulk cargo carrier

PORT	Iron ore	Coal	Stone	Sand & Gravel	Lime-stone	Grain	Cement	Petroleum
CHICAGO, IL (with CALUMET, IN)	I	E			I	E		
DULUTH, MN	E	I				E		
TOLEDO, OH	I	E				E		
GREEN BAY, WI		I	I					I
BUFFALO, NY	I	E			E	I		
DETROIT, MI	I	I			I		I	
CLEVELAND, OH	I			E	I			
SARNIA, ONT						E		E

Table 1. Examples of products carried between Great Lakes ports. (I = Imported to the port; E = exported from the port.)

Answers

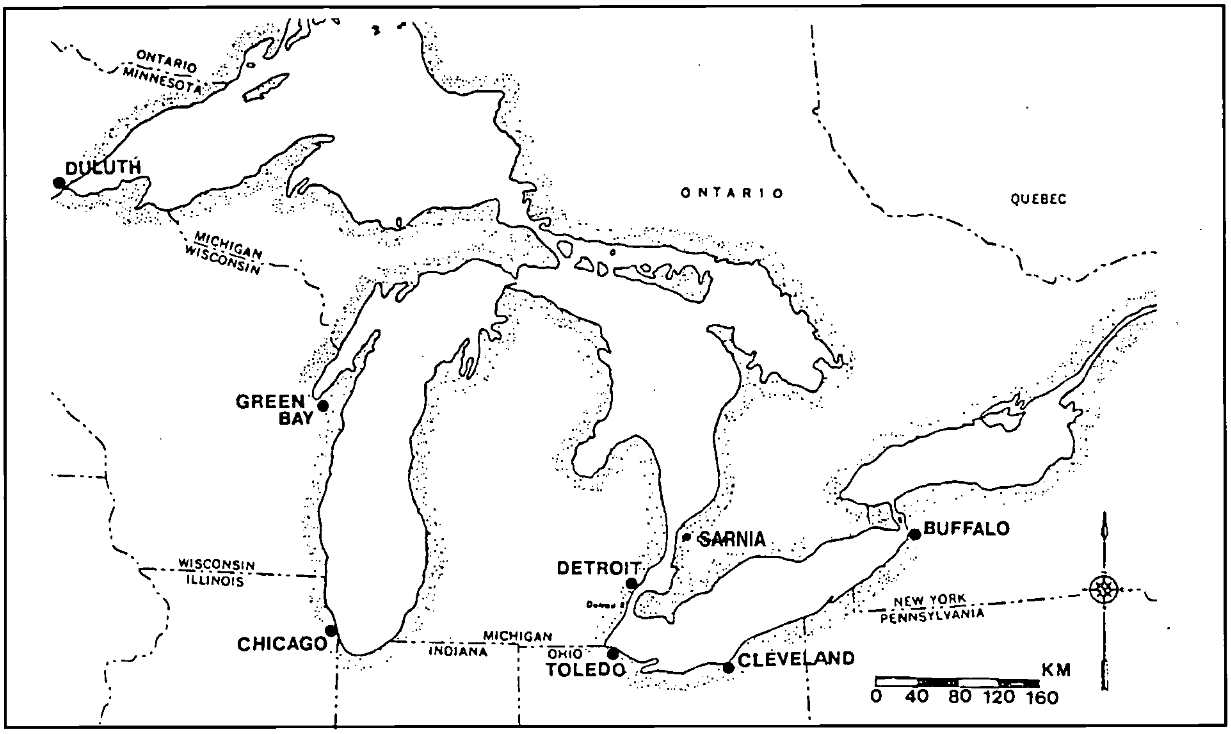
1. Duluth is the one city that exports iron ore. It is located near the Mesabi Iron Range, the major iron ore producing region in the country.
2. Chicago, Toledo, Buffalo, Detroit, and Cleveland.
4. According to the information students are given, the only thing that Duluth imports is coal; therefore, only Toledo and Buffalo would have anything to send back on the ships to Duluth. This, however, is not completely true. There may be other types of cargo that Duluth needs from other ports, but many of the bulk carriers return to Duluth with only ballast water.
5. Green Bay probably imports coal and fuel oil, because it does not have a local source of these energy supplies. Both are used for generation of electricity and for industrial power sources.
6. Grain is exported by Chicago, Duluth, and Toledo. Buffalo imports grain.

Procedure

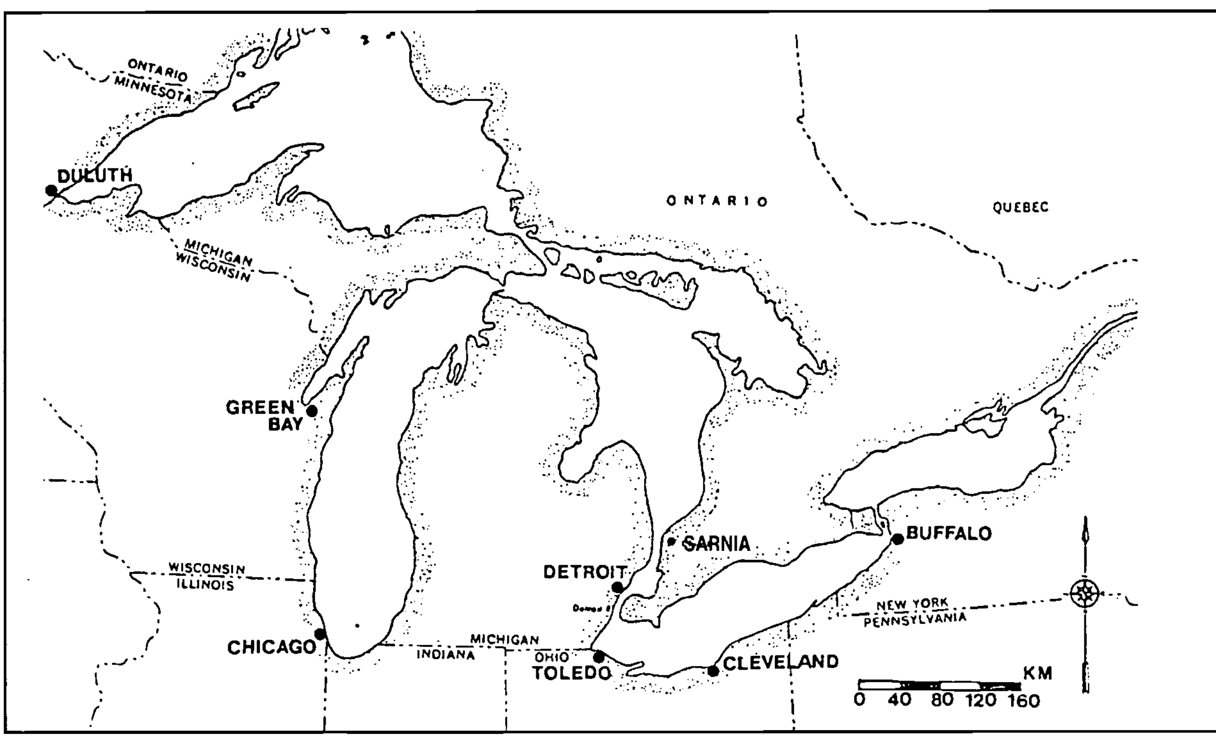
Study the data in Table 1 and answer the following questions.

1. Which city exports iron ore?
2. Which cities import iron ore?
3. On Map 1, draw possible routes for the transportation of iron ore using arrows to show the direction in which the ships would move. The product will move **from** a city of export **to** a city of import.
4. What products could these ships carry on their return trips?
5. Why might Green Bay import coal and fuel oil (petroleum)?
6. What cities export grain? What city imports it?
7. On Map 2, draw transport routes for grain using arrows to show the direction in which the ships would move.

Student Worksheet



Student Map 1. Shipping Routes for **Iron Ore** on the Great Lakes.



Student Map 2. Shipping Routes for **Grain** on the Great Lakes.

8. According to the information provided, ships returning to Duluth could take coal from Buffalo; those returning to Chicago could carry limestone. Toledo does not import anything that Buffalo exports. Again there may be other bulk cargos that the ships could carry; however, many of them probably return to their ports empty.
9. Detroit produces steel required in automobiles. All three products are necessary in the production of steel.
10. Cement, sand, and gravel are used in construction of buildings and highways, both for concrete and in what is called road metal, which is loose material used under the highway to promote drainage.
11. Buffalo is one of the largest railroad centers in the United States. Grain is unloaded there for rail transport to be distributed throughout the East.

8. What products could these ships carry on their return trips?
9. What product does Detroit produce that requires the import of iron ore, limestone, and coal?
10. What might be the use of cement, sand, and gravel?
11. Why would most of the grain be transported to Buffalo?

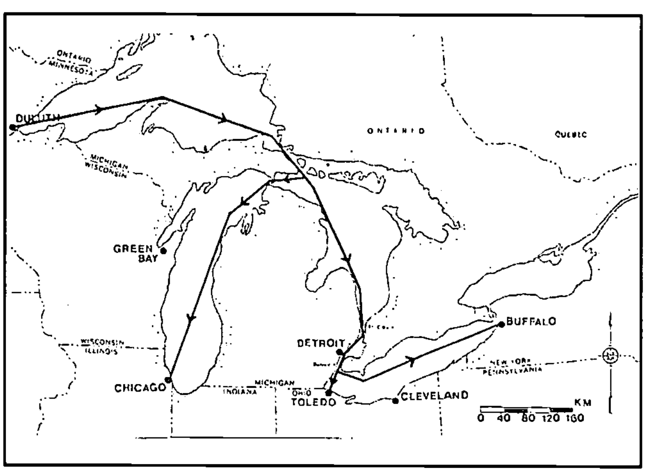
Review Question

What are some products that are transported across the Great Lakes? Most of these are considered <u>bulk</u> products. From what they have in common, how would you define bulk?

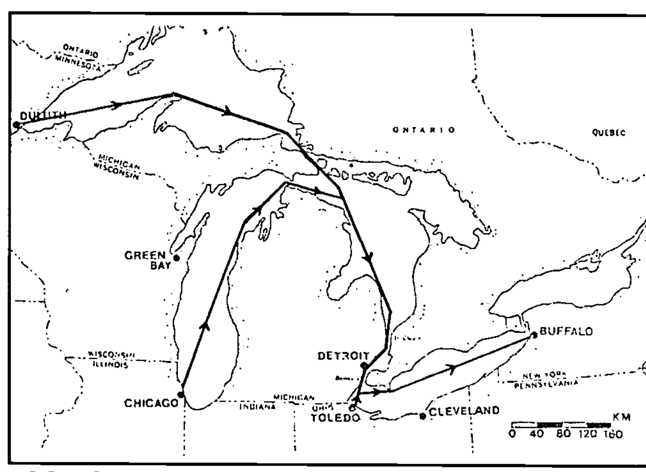
Extension

Compare the export and import areas with what you can learn of Great Lakes geography. Examine the Internet sites for the states to find out the economic value of the imports and exports.

Teacher Guide to maps that students produce in this activity.



Map 1 Key. Iron ore.



Map 2 Key. Grain.

What is the most economical form of transportation?

Lake shipping is the major form of transportation used for shipping bulk products such as grain and iron ore. Farmers and mining companies charge a very low price for each pound or kilogram of their product. Therefore, the cost of transportation of bulk products must be very low. If not, the cost of transportation would be a major part of the cost of the final product, such as bread or metal. Manufacturers, on the other hand, must charge a high price per pound or kilogram for their products because of manufacturing costs. Therefore, the cost of transportation, as long as it is not very, very expensive, will not add much to its final price. In this activity you will learn why lake shipping is the best way to transport bulk cargo.

OBJECTIVES

In this activity you will be able to compare various forms of transportation in terms of their cost and speed.

PROCEDURE

1. On Map 3, draw lines from Duluth to Chicago, Chicago to Cleveland, and Cleveland to Buffalo. **Do not let any of your lines cross any part of a lake.** These are the general routes followed by railroads and trucks.

2. On the same map, using a different color, draw the shortest possible route for a ship going from Duluth to Buffalo.

Source

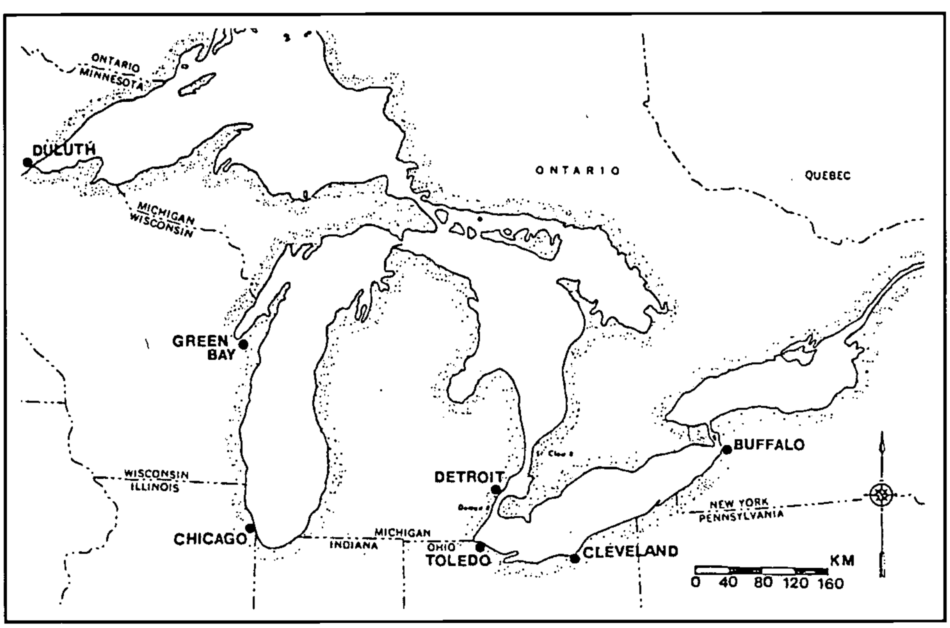
OEAGLS EP-13.*Shipping on the Great Lakes,* Activity B, by Keith N. Schlarb and Victor J. Mayer.

Earth Systems Understandings

This activity focuses on ESU 3, science processes and data, and 2, human impacts.

Materials

- String for measuring distances.
- Calculator (optional).
- 2 colored pencils per pair of students.



Student Map 3. Land and Water Routes in the Great Lakes Region.

3. Determine the length of each route (the land route and the ship route) by laying a string along the route exactly covering the lines you have drawn. Then use the map scale to convert the string length to kilometers—the distance between Duluth and Buffalo. Enter your answers in the table at the bottom of this page. [Distances between ports are also available on the Internet at the Lake Carriers Association site.]

4. Suppose your company wanted to transport 600 metric tons of coal from Duluth to Buffalo. Which method of transportation would you use? Why?

Answers

4. At this point, students have no basis for selecting one or the other of the methods of transport. Ask them to justify any choice that they do make, but do not imply that there is a right or wrong answer to this question at this point.

NOTE: Figures in the table are from 1987. Students can investigate how to obtain current figures.

The following table gives the cost (in U.S. dollars) of moving one metric ton of coal 100 km for each transportation method. One metric ton is equal to 2,200 lbs.

METHOD	COST
Railroad	$1.23
Highway	$3.74
Water	$0.07

5. Determine the total cost of transporting your coal by each method of transportation. Use the following formula.

$$\text{COST} \times \text{METRIC TONS} \times \frac{\text{DISTANCE (km)}}{100} = \text{TOTAL COST}$$

Enter your answers on the chart.

Student answer chart for economics and energy efficiency activities.

TRANSPORTATION METHOD	Duluth to Buffalo			Chicago to Toledo		
	Distance	Total Cost	Fuel	Distance	Total Cost	Fuel
Railroad						
Highway						
Water (lake freighter)						

6. Which is the cheapest method of transporting cargo from Duluth to Buffalo? Does this match your choice of method in question #4?

7. Why would you want to use this method to transport bulk cargo such as grain and iron ore rather than manufactured goods such as cars?

8. Determine the distance from Chicago to Toledo for the three transportation methods. Enter your answer on the chart.

9. Determine the cost of transporting 600 metric tons of coal by each of the three transportation methods. Enter your answer on the chart.

10. What is the cheapest method of transporting cargo from Chicago to Toledo?

11. How does this compare with costs from Duluth to Buffalo?

12. How many times more costly is the next cheapest method than the cheapest method of transportation between Duluth and Buffalo? To determine this, divide the total cost of the cheapest method into the total cost of the next cheapest method.

13. Now do the same for the Chicago to Toledo route.

REVIEW QUESTION

Would companies be more likely to ship coal by rail between Duluth and Buffalo or between Chicago and Toledo? Why?

EXTENSION

Compare the distances over which the different commodities are shipped. Distances can be measured or found on the Internet site for the Lake Carriers Association. Develop a simple spreadsheet program that will calculate the cost of shipping by each transportation method regardless of the amount of goods you insert in the program. Discuss the relative importance of the cost consideration when the product being shipped is grain versus when it is new automobiles.

6. The cheapest method from Duluth to Buffalo is by water.

7. Grain and iron ore have a very low cost per pound or kilogram, so the method of transport has to be very inexpensive. If not, the cost of transport will approach the price paid for the cargo, making the end product, bread or steel, quite expensive. Cars, on the other hand, are very expensive in comparison to bulk cargo. Therefore, even using expensive means of transportation, the cost of transportation per pound or gram will be relatively low. Speed of transport becomes more important, so that the cars can be sold quickly, allowing the producing company to get its investment back more rapidly

8-9. Chicago to Toledo

	Distance	Cost
Railroad	330 km	$2435.40
Highway	330 km	$7405.20
Water	880 km	$ 369.60

10. Even though the distance of the water route is almost three times that of the land route, water is still the cheapest.

11. Both are cheaper by water.

12. Transporting materials by water between Duluth and Buffalo costs about a tenth that of transporting them by railroad. You might point out to students that truck transportation is 53 times as expensive as water transportation over that distance.

13. Rail transportation costs about four times that of water transportation between Chicago and Toledo. It costs about 10 times as much to transport by truck. Because of the disparity in the length of the transportation routes, a great deal of the cost advantage of water transportation has been lost.

14. Because of the great cost advantage, companies would be much more likely to ship coal by water between Duluth and Buffalo. Between Chicago and Toledo the cost advantage, although still sizeable, is not quite as great. There might be instances, then, of coal shippers using the railroad, especially if time was a factor.

Which transportation method uses the least energy?

The world is now facing many problems related to the use of fossil fuels such as oil, coal, and gas. Much of the oil needed by the United States is brought in from other countries, causing problems in our economy. When burned, fossil fuels give off carbon dioxide, a gas that remains in the air. Many now believe that adding more of the gas is causing the world's climate to change. To control these problems, we must become much more efficient in our uses of energy. Much of our energy is consumed by transporting materials. Are we using the most energy efficient methods?

OBJECTIVES

When you have completed this activity you will be able to:

- Compare transportation modes in terms of energy efficiency.
- Analyze the environmental impacts of various transportation methods.

The table below gives the number of metric tons of material each method can transport a distance of 1 kilometer using 1 liter of fuel.

Transportation Method	Fuel Efficiency
Railroad	40 mt/l/km
Highway (Truck)	12 mt/l/km
Water (Freighter)	99 mt/l/km

Source

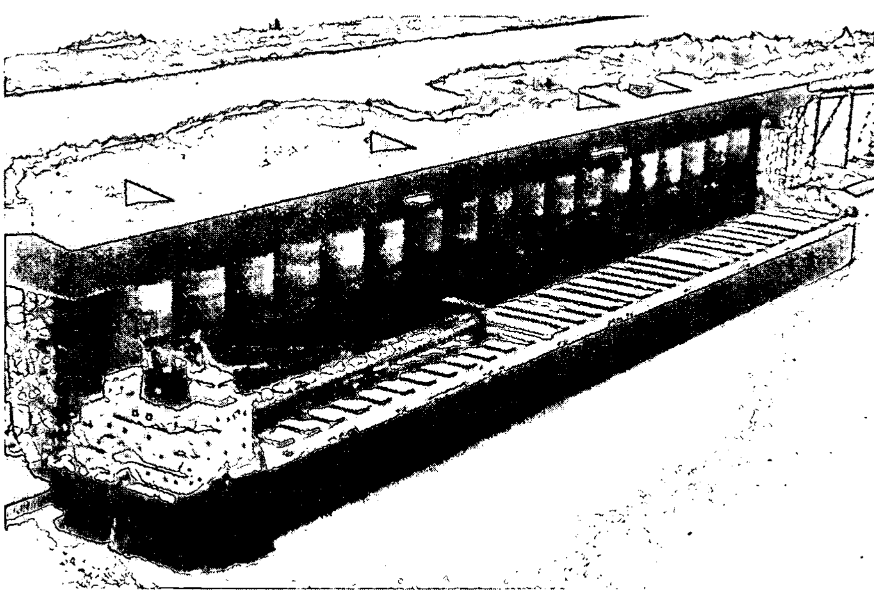
OEAGLS EP-13, *Shipping on the Great Lakes*, Activity C, by Keith N. Schlarb and Victor J. Mayer.

Earth Systems Understandings

This activity focuses on ESU 2, human impacts, and 3, science processes and data.

Materials

- Completed table from previous activity.
- Calculator (optional).



A self-unloading ore carrier. (Meakin Collection)

PROCEDURE

In this activity you will calculate the total amount of fuel required to transport the 600 metric tons of coal from Duluth to Buffalo. To do this, divide the 600 metric tons by the amount of fuel required for the transportation method (fuel efficiency). Then multiply by the total distance transported to find the total number of liters of fuel that would be needed.

$$\frac{600 \text{ MT}}{\text{FUEL EFFICIENCY}} \times \text{DISTANCE} = \text{TOTAL AMOUNT OF FUEL}$$

1. Using the distances you calculated in Activity B, determine the amount of fuel required to transport 600 metric tons of coal from Duluth to Buffalo for each transportation method. Enter your answers in the Fuel column of the same chart.

2. Which is the most energy-efficient method for this trip?

3. Determine the amount of fuel required for each method in the trip from Chicago to Toledo. Enter your answer in the Fuel column of the chart

4. Which is the most energy efficient method for this trip?

5. Does this agree with the cheapest transportation method for this trip? See question 10 of the previous activity.

6. As energy becomes more expensive and perhaps more scarce, which transportation methods are likely to become more popular between Duluth and Buffalo? Why?

7. Between Chicago and Toledo? Why?

Answers

1,3.

	Duluth-Buffalo	Chicago-Toledo
Rail	13,615	3,808
Trucks	47,200	13,200
Water	5,953	4,093

2. On the Duluth to Buffalo route, water is the most efficient method.

4. Because of the shorter distance, railroads are the most energy efficient in carrying freight from Chicago to Toledo. Point out to students that trucks require four times the amount of energy of either railroads or water.

5. Even though railroads are the most energy efficient, over this route they are not the cheapest. This is because of the great labor required on railroads, both for running the trains and for maintaining track.

6. We would expect that water transportation will become more and more important between Duluth and Buffalo. Even manufactured goods will likely be transported in this manner.

7. Between Chicago and Toledo, we might expect truck transportation to become less important because of its low energy efficiency. Railroads could take on an increasing share of the transportation of materials from trucks and perhaps even from water transport. Canadian railroads are already used extensively for transport.

Environmental Impact

Each of the three methods of transportation affects the environment in different ways. Ships, for example, use the surface of the water, whereas highways must be constructed to carry trucks.

8. In teams of two or three, identify as many ways as you can that each of the methods of transportation affects the environment.

9. Which method do you think has the greatest effect on the environment? Why?

REVIEW QUESTIONS

1. Which is the most energy-efficient method of transportation?

2. Which of the methods of transportation has the least impact on the environment?

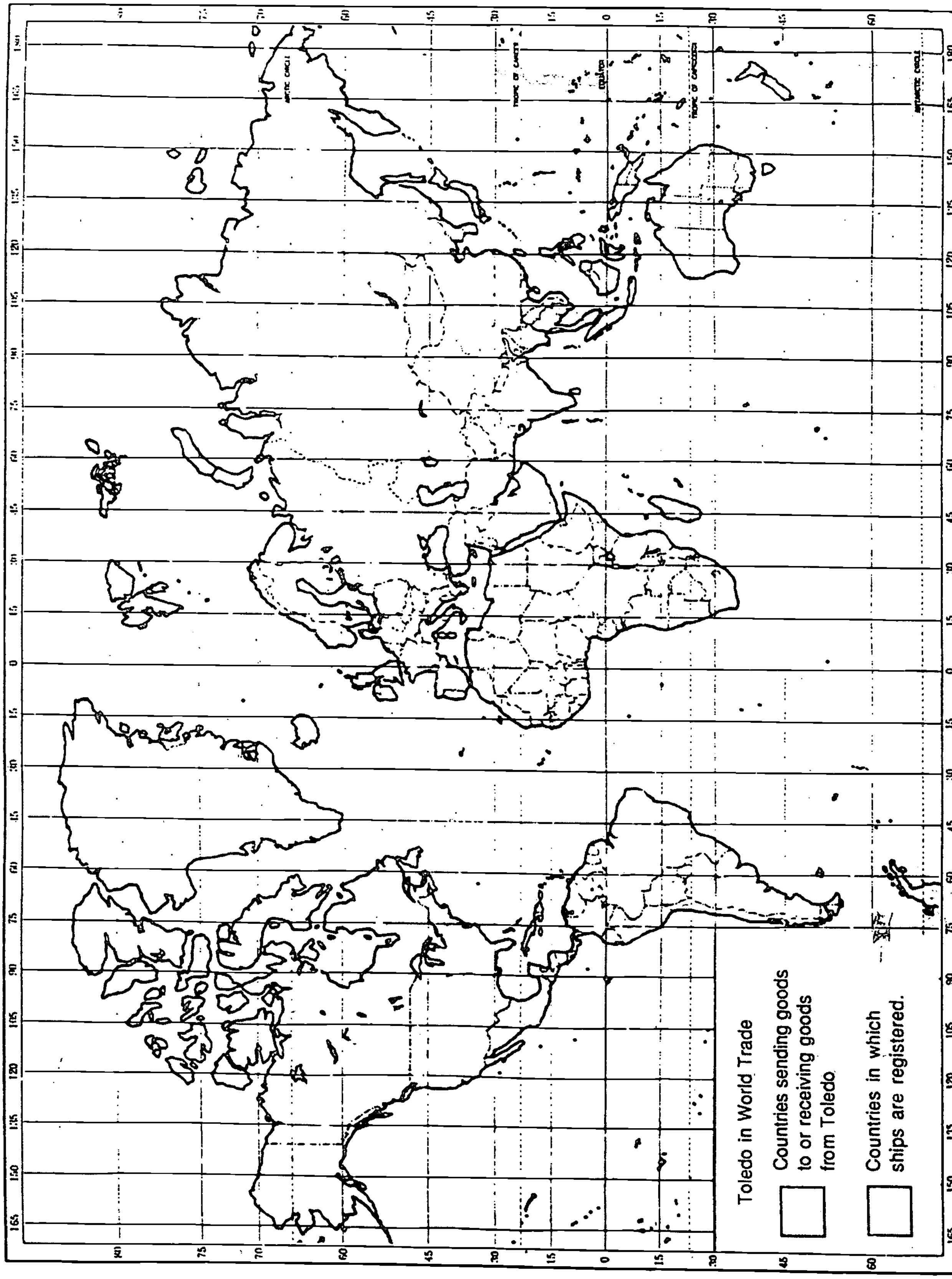
3. What do you think will happen with the use of lake freighters in the future? Railroads? Trucks? Explain your reasons.

8. Accept any reasonable ideas the students suggest. It would be good to have a class discussion on this topic.

   Ideas you might expect include:
   - road and track construction (erosion)
   - safety for others using same methods
   - noise and sight pollution
   - air pollution, including acid deposition
   - impact of accidental spills

9. This may be a difficult question for the students to answer. Discuss the reasoning behind answers offered. If we are considering the negative impact upon the environment per pound or kilogram of material carried, then trucking would have the greatest negative impact because of its extremely low fuel efficiency. This means that much more fuel must be burned, producing a much greater quantity of pollutants than either of the other forms of transportation. In addition, since trucks travel the same roads as you and I, hazards they cause, such as possible accidents, are more likely to impact us.

27


Toledo in World Trade
Countries sending goods to or receiving goods from Toledo
Countries in which ships are registered.

Where go the boats?

When the United States of America proclaimed itself in 1776 to be an independent nation, all of its cities were busy sea ports. The young nation clung to the ocean, finding there a source of food, an avenue for trade, and a barrier against the powerful nations of Europe. Two hundred years later the population centers of America are still linked to bodies of water. In fact, more than three-fourths of the U.S. population can be found in those states which border the Great Lakes and the ocean.

—*G. Mangone, Americans and the World of Water*

Our waterways connect us with the rest of the world. The Great Lakes have 22 international deep-water ports joined to the world ocean by a series of locks and channels called the St. Lawrence Seaway. The system creates a waterway 2,340 miles (3,774 km) long, through which goods may be shipped to and from the heart of North America.

"Green leaves a-floating,
Castles on the foam,
Boats of mine a-boating,
Where will all come home?"

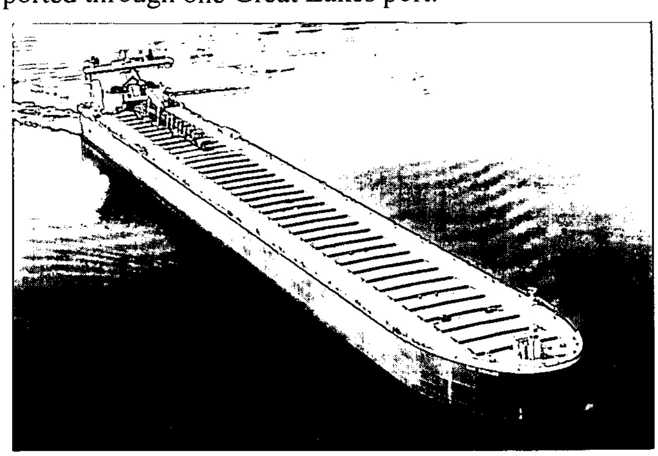
–*Robert Louis Stevenson, "Where Go the Boats?"*

Ships flying the flags of over 50 nations regularly use the trade routes of the Great Lakes. They make these waterways the world's most important inland water transportation system by connecting interior America with the markets of the world.

OBJECTIVES

When you have completed this activity, you should be able to:

- Discuss the importance of the Great Lakes in world shipping.
- Explain what is meant by the registry flags of commercial ships.
- Summarize the main types of products imported and exported through one Great Lakes port.



Source

Activity A, OEAGLS EP-20, *Shipping: The World Connection*, by Rosanne W. Fortner, The Ohio State University, and Ray Pauken, Columbus City Schools.

Earth Systems Understandings

This activity focuses on ESU 3, science processes and data, and 4, interactions. ESU 7, careers, is applied in Extensions.

Materials

- Reference map of the world.
- Two colored pencils per team.
- Outline map of the world (Map pg. 24).
- Cargo information from the Port of Toledo for a portion of one year (Table 1).
- Two colored pencils per map.
- World map (political) for reference.

NOTE: Information to teachers is enclosed in boxes in this guide.

Procedure

A. Find the Great Lakes on your world map. Label the Port of Toledo (on Lake Erie) with an X.

B. Look at the International Shipping (Table 1, pages 29-31) for the Port of Toledo. Notice the columns labeled "From" and "To." These tell you where a ship is coming from (its last port) and where it is going next. For some ships, these ports were not known.

C. Now look at the column labeled "Flag." This tells the country in which a ship is registered. The ship flies that country's flag.

D. Use one colored pencil to shade in all those countries listed under either "To" or "From" for the ships given. Use a reference map to find out where these countries are.

E. With a second colored pencil, make slash lines through any country listed in the "Flag" column.

Answer the following questions based on the table and your completed map.

1. The shipping season opens when shipping lanes and locks are free of ice. When did the shipping season open in this example year?
2. When did the season close? Why?
3. About how much of the world was affected by trade with the Port of Toledo in this example year?
4. Which two flags are most frequently flown by international trade ships using the Port of Toledo?
5. Did ships flying these flags actually sail to or from those countries?
6. Are these countries the leaders in world trade? (Consult the World Almanac for recent years.) Discuss this answer with the rest of the class.
7. Classify Toledo's outgoing products (exports) as being foods, manufactured goods, timber, or miscellaneous. For each continent, tally the number of ships carrying each type of product out of Toledo and record the numbers in the chart provided.

Answers

A-E. Students use the International Shipping tables to construct a two-colored map, or one map in one color overlaid by a transparency with the other color. To find all the countries needed, they should have access to a standard world map or large globe. For younger students, you may need to mark the tables to indicate the continent for each country. Also, small reference maps sometimes do not show Cyprus and Malta. Both are islands in the Mediterranean Sea.

1. The shipping season opened in April.
2. The season closed in December because of ice in the shipping lanes and locks.
3. Two-thirds to three-fourths of the world was affected by trade through Toledo in this example.
4. Flags of Greece and Yugoslovia.
5. Ships under those flags did not come or go from those countries.
6. The countries are not leaders in world trade. This discussion calls for speculation by the students. Accept all reasonable answers and discuss them. According to Robin Burton ("Flags of Convenience," *Sea Frontiers* 21(5): 294-302), a person who owns a merchant ship and registers it in another country to save money on taxes and wages is using that country's flag for convenience. In the recent past (up until about 1975), many of these convenience countries did not require inspection of vessels or training credentials for crew members. It was not uncommon for safety conditions to be neglected, ships to fall into disrepair, and crew members to be speaking five different languages. Now, international regulations are tighter, and many ships under flags of convenience are there for fuel savings and income tax relief only, with safety and training standards checked regularly.

8. Classify imports as being foods, manufactured goods, raw materials for industry, and miscellaneous. For each continent, tally the number of ships carrying each type of product into Toledo, and record the numbers in the chart.

9. With which continent does the Port of Toledo carry on the most trade?

10. What is the main export to that continent?

11. What is the main import from that continent?

12. Based on the imports chart, what is one of the main industries in Europe?

13. Based on the exports chart, what U.S. products do the developing nations of Africa need most?

14. The ships on the Port listing carry different amounts of the cargoes listed. If you consider the number of ships only, which is greater from the Port of Toledo, imports or exports?

9. Europe provides most of the trade through Toledo.

10. The main export to Europe is food.

11. The main import is raw materials for industry.

12. From the list of raw materials on pages 5-7 of the Student Guide, mining (to get the raw materials) is shown to be a major European industry.

13. Africa gets food through Toledo.

14. Exports exceeded imports in this example year.

TOLEDO EXPORTS

Product	Number of Ships to: Europe	Asia	Africa	South/Central America
Food				
Raw Materials for Industry				
Manufactured Goods				
Miscellaneous				

TOLEDO IMPORTS

Product	Number of Ships from: Europe	Asia	Africa	South/Central America
Food				
Raw Materials for Industry				
Manufactured Goods				
Miscellaneous				

Toledo is only one of 22 deep water ports on the Great Lakes. Using the information from this activity, based on part of one year's shipping from one port, you can probably begin to see how important the Great Lakes are in world trade.

15. Railroads and trucks would have to transport goods if the St. Lawrence Seaway were not available. These are less energy-efficient and more expensive forms of transport. See ES-EAGLS activities in this set: What is the most economical . . . and which transportaion method uses the least energy?

15. If ocean going ships could not reach Toledo and other Great Lakes ports, how would U.S. products have to be transported?

1977	Total Seaway Tonnage	63.4 Million Tons
1978	Total Seaway Tonnage	62.8 Million Tons
	Total bulk shipments (grain and iron ore)	57.7 Million Tons
	Total tonnage handled at Duluth-Superior alone	45.9 Million Tons
	Number of ocean-going ships in Soo Locks	378
	Number of countries represented	32

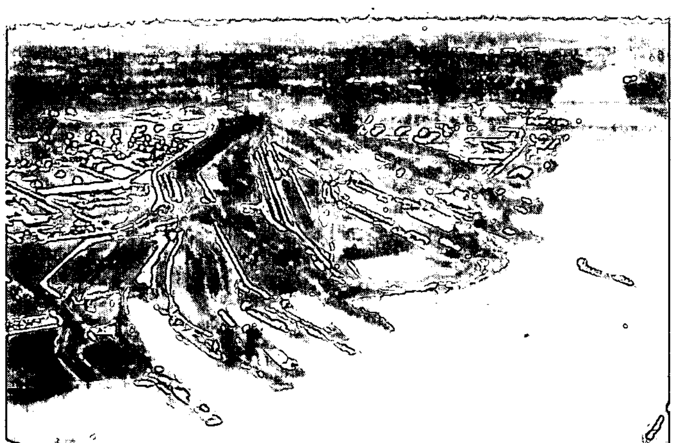


Photo of the Port of Toledo

1995 ANNUAL REPORT of the Lake Carriers Association

The vast majority of these cargos were carried by U.S. and Canadian lakers. Third-flag vessels participate primarily in the export grain trade.

GREAT LAKES DRY- AND LIQUID-BULK COMMERCE: 1995-1994 (net tons)

	1995	1994
IRON ORE		
From Lake Superior	50,733,237	51,100,995
From Lake Michigan	8,156,539	7,382,654
From Eastern Canada	11,703,550	11,633,096
Total Iron Ore	**70,593,326**	**70,116,745**
COAL		
From Lake Superior	15,270,969	15,823,338
From Lake Michigan	1,131,491	796,124
From Lake Erie	16,541,326	18,382,318
Total Coal	**32,943,786**	**35,001,780**
LIMESTONE, GYPSUM		
From U.S. Ports	30,947,398	29,675,439
From Canadian Ports	3,617,310	3,162,876
Total Stone	**34,564,708**	**32,838,315**
SALT	**6,717,037**	**7,510,169**
CEMENT	**4,617,555**	**4,652,255**
POTASH	**657,256**	**666,918**
Total Dry-Bulk Cargo	**150,093,668**	**150,786,182**
LIQUID BULK	**4,730,467**	**4,628,346**
Total All Commodities	**154,824,135**	**155,414,528**
GRAIN	**18,800,637**	**18,107,236**
Total Including Grain	**173,624,772**	**173,521,764**

To convert iron ore to gross tons, multiply by .89286

Table 1. PORT OF TOLEDO
INTERNATIONAL SHIPPING
(a portion of one year)

Vessel Name	Flag	Cargo In	From	Cargo Out	To
April					
Hermine	France	—	—	Soybeans	Spain
Arkandros	Liberia	—	—	Jeeps	Morocco
Makarska	Yugoslavia	Wine	Italy	Timber	Italy
Paula L. Russ	Germany	Machinery	Germany	Timber	Germany
Baltic Skou	Denmark	Chrome Ore	Norway	—	—
Redsea Venture	Liberia	Liquid Fertilizer	Netherlands	—	—
Span Terza	Italy	Foundry Coke	Belgium	—	—
Eglantine	France	Steel	France	—	—
Sealord	Panama	—	—	Wheat	Morocco
Parthenon	Greece	—	—	Corn	England
May					
Comas	Singapore	—	—	Soybeans	Russia
Thurdrecht	Netherlands	—	—	Corn	Scotland
Hilary B	Singapore	Raw Sugar	Panama	—	—
Tozui Maru	Japan	—	—	Soybeans	Japan
Kapitan Panfilov	Russia	Aluminum	Russia	—	—
Zabrze	Poland	—	Europe	Timber	Belgium
Milanos	Spain	Steel	Italy	—	—
Jadro	Yugoslavia	Miscellanous	Italy	—	—
Valya Kotik	Russia	—	Europe	Timber	Netherlands
Auctoritas	Italy	—	—	Soybeans	Italy
June					
Peter L	Greece	Raw Sugar	Honduras	Wheat	Algeria
Victoria Faith	England	—	—	Corn	Morocco
Lake Aniara	Norway	Liquid Fertilizer	Netherlands	—	—
Arctic	Canada	—	—	Corn	Belgium
Rubens	England	Foundry Coke	Germany	Corn	W. Germany
Delchim Cevennes	France	—	—	Petroleum Prod.	France
Federal Calumet	Liberia	Furnace Coke	Germany	Corn	Netherlands
Lynton Grange	England	Steel	England	—	—
George L	Greece	Furnace Coke	Belgium	Corn	Netherlands
Union Pride	Greece	Miscellanous	Canada	Autos	Chile

Vessel Name	Flag	Cargo In	From	Cargo Out	To
July					
Shura Kober	Russia	—	Europe	Cob Pellets	England
Baam	Netherlands	Machinery	Germany	Machinery	Netherlands
Hosei Maru	Japan	—	—	Soybeans	Japan
Teesta	India	Steel	India	Wheat	Algeria
Zabat-Dos	Spain	Zinc	Spain	Corn	Spain
Marcos Souza Dantos	Brazil	—	Brazil	Machinery	Brazil
Koper	Yugoslavia	—	—	Wheat	Nigeria
Lake Katya	Liberia	Liquid Fertilizer	Netherlands	—	—
Sugar Crystal	England	Steel	England	—	—
Satya Kamal	India	Chrome Ore	Norway	—	—
August					
C. Mehmet	Turkey	Steel	France	—	—
Carchester	England	—	England	Corn	England
Kiyo	Liberia	—	—	Soybeans	Japan
Katherine	Greece	—	—	Corn	Scotland
Prvi Februar	Yugoslavia	Furnace Coke	Belgium	—	—
Blumenthal	Germany	—	Ecuador	Miscellanous	Venezuela
C. Tahsin	Turkey	Steel	Belgium	—	—
Shirley Lykes	America	—	Italy	Machinery	Egypt
Tilly Russ	Germany	Miscellanous	Europe	Miscellanous	Europe
Dubrovnik	Yugoslavia	—	—	Corn	Scotland
September					
Puhos	Finland	Urea	E. Germany	—	Duluth, MN
Hand Fortune	Panama	—	—	Corn	England
Zambrow	Poland	—	Belgium	Timber	Belgium
Adriatik	Yugoslavia	Furnace Coke	Belgium	Soybeans	Belgium
Torm Kristina	Denmark	—	—	Soybeans	Netherlands W. Germany
Ektor	Greece	Steel	France	—	—
Federal Clyde	England	—	—	Soybeans	W. Germany
Arkandros	Greece	—	—	Corn	Malta
Split	Yugoslavia	Miscellanous	Greece	Miscellanous	Yugoslavia
Meltemi II	Greece	—	—	Corn	England
October					
Ever Honor	Cyprus	—	—	Soybeans	Netherlands
Totai Maru	Japan	—	—	Soybeans	Japan
Harmonious	Panama	Chrome Ore	Norway	—	—

Vessel Name	Flag	Cargo In	From	Cargo Out	To
Jean Lykes	America	—	Italy	Machinery	Egypt
Murray	Liberia	—	—	Soybeans	Japan
Zamosc	Poland	Zinc and Machinery	Belgium	Timber	Netherlands
Zinnia	England	—	—	Soybeans	Germany
Lena	Greece	—	—	Corn	Scotland
Providence	Panama	Furnace Coke	Germany	—	—
Caspiana	Greece	—	—	Corn	Italy
November					
Boujniba	France	—	—	Corn	E. Germany
Atlantic Helmsman	Greece	Furnace Coke	Germany	Soybeans	Spain
Paul L. Russ	Germany	Miscellanous	Germany	Timber	Germany
Ondine	France	Steel	France	Wheat	China
Dunav	Yugoslavia	—	—	Soybeans	W. Germany
Kara	Finland	Metals	Finland	—	—
Efploia	Greece	Furnace Coke	Germany	—	—
Federal Seaway	Greece	—	—	Soybeans	Indonesia
Olympic Hope	Greece	Furnace Coke	Germany	Corn	Germany
Ashley Lykes	America	—	Italy	Machinery	Italy
December					
Thorswave	Norway	—	—	Timber	Germany
Federal Rhine	Liberia	—	—	Corn	Germany
Tokei Maru	Japan	—	—	Corn	England

Review Questions

1. List the continents that send goods to or receive products from a typical Great Lakes port.

2. What is the main type of product exported through the Port of Toledo? through the Lake Carriers in general?

3. What is the main type of product imported?

4. What determines the length of the Great Lakes shipping season?

5. Why might a company register its ships in a foreign country if the ships do not trade with that country?

Extension

Compare the shipping season and types of cargo exchanged at a port near your location. See if you can account for the differences and similarities based on climate, local economics, transportation available, and other factors.

References

Great Lakes Shipping Today (Lake Carriers Association)
http://little.nhlink.net/wgm/lca/today.html

Great Lakes shipping schedules
http://www.acs.oakland.edu/~ncschult/boatnerd.html

Great Lakes Bookshelf (Harbor House Publishers)
http://www.harborhouse.com/bookshel.htm

Great Lakes buoy data
http://www.ems.psu.edu/wx/regions/greatlakes.html

Lake Carriers Association Web page
http://www.en.com/lcaships/

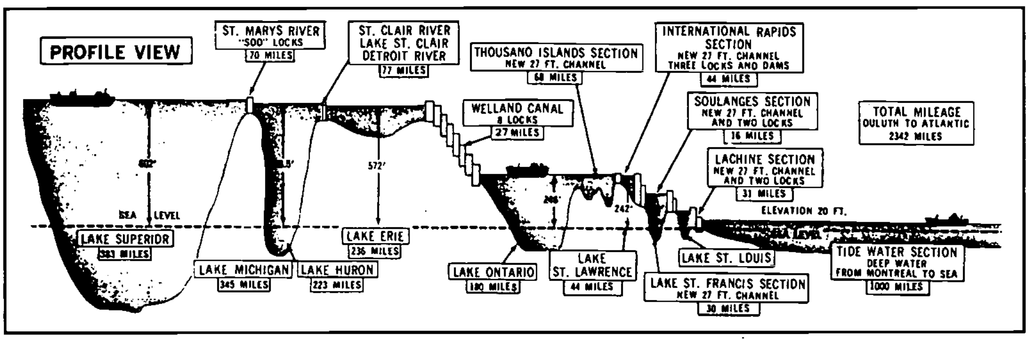
Maps
http://www.great-lakes.net:2200/ecosystem/tools/maps.html

U.S. Army Corps of Engineers
http://sparky.nce.usace.army.mil

Address for other information:
Lake Carriers Association
915 Rockefeller Bldg.
Cleveland, OH 44113-1306
(216)621-1107

How do ships get from one lake to another?

Lake Superior is 602 feet (184 meters) above sea level. To allow ships to go from the Atlantic Ocean (0 feet [0 meters] elevation) to the Great Lakes and back for international trade, the United States and Canada have constructed a series of locks that raise and lower ships to the levels of the lakes, rivers, and ocean. Because of this system, 80 percent of the world's cargo ships can now sail as far west as Lake Superior. Here is a diagram of where the locks are located and how much lift they must provide. Notice that not all of the connecting channels between lakes have a change in elevation.



U.S. Army Corps of Engineers

Objective

When you have completed this activity you should be able to describe to a classmate how navigational locks operate to raise and lower ships through the Great Lakes.

Procedure

Navigational locks demonstrate how science and technology can work together to solve difficult problems. Not all technologies are as benign as locks, but even they have some negative aspects. Think about technologies you use and how they might have some negative effects at the same time they are helping you.

Source

OEAGLS EP-20B. *Shipping: The World Connection,* by Rosanne W. Fortner and Ray Pauken

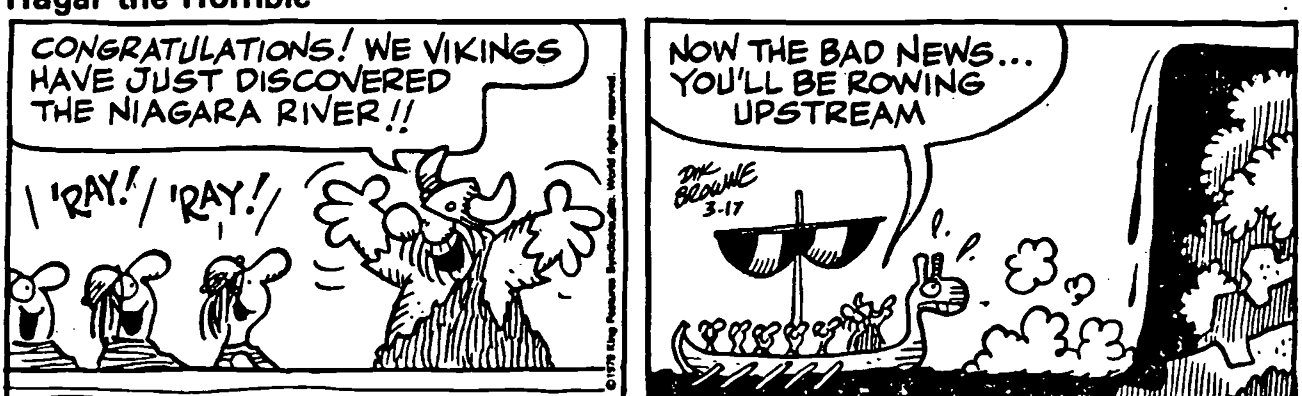
Earth Systems Understandings

This activity focuses on ESU 3, scientific thinking and technology.

Materials

- Two half-gallon or quart milk cartons.
- Small toy boat.
- Scissors or sharp knife.
- Modeling clay or fiber tape.
- Water.
- Sink or stream table.

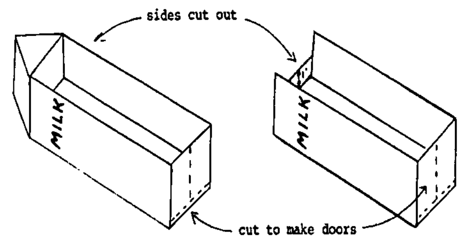
Hagar the Horrible



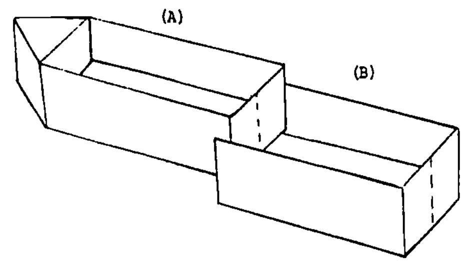
Reprinted with special permission of King Features Syndicate.

You can construct a model of a lock and use it to raise and lower a boat to three different water levels.

A. Cut two milk cartons as this picture shows.

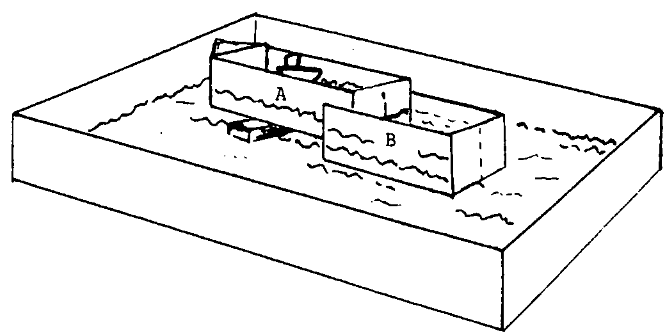


B. Connect the two cartons as shown below, using modeling clay or heavy tape around the edges to be sure water will not leak out where the cartons are joined together.



C. Add water to a sink or stream table to make an "ocean" about 5 cm deep. Put your model locks into the "ocean" with the open side up and all doors tightly closed.

D. Pour water into Carton B until it comes up to meet the bottom edge of Carton A. Then pour about 5 cm of water in Carton A. Place a small toy boat in Carton A. You may need a block of wood to prop up the end of A. Your setup should look like this:



Teacher's Notes

Carefully supervise the construction of locks if it is done in class. Sharp paring knives work best for cutting the doors. You may prefer to have certain students construct the locks at home with adult supervision.

Note the small lip at the bottom of the doors. This helps keep the doors closed. You may also need bits of modeling clay or paper clips to keep the doors closed at the top when the lock has water inside.

While the models are being used, point out to students the differences between their models and the way real locks work, as illustrated later in the activity.

The pictures on the next page show how locks operate to raise and lower ships to the different levels of the St. Lawrence Seaway.

E. Slowly open the doors of Carton A to let the water levels in A and B become the same. Move the boat into Carton B.

F. Open the doors of Carton B slowly and let the boat move out into the ocean.

G. To bring the boat back upstream do the following:
1. Open the doors of B and move the boat into Carton B.
2. Close the B doors and open the A doors.
3. Add water to Carton A until the boat is raised higher than the bottom of Carton A. (The water for filling real lock chambers always comes from the upstream lake or river).
4. Move the boat into Carton A.
5. Close the A doors and add water to the original 5 cm depth. Your boat is now ready to enter the upstream areas at this higher level.

H. With your team, answer the following questions about what you have learned:

1. In an actual lock system, what does Carton A represent?
2. Where does the water go when it flows out of B (in a real situation)?
3. During which steps would the emptying valve be open? Closed?
4. During which steps would the filling valve be open? Closed?
5. When the lock gates are opened, the level of water in the lock chamber is the same as which other water level?
6. What could you do to your model to make it operate more realistically?

Answers

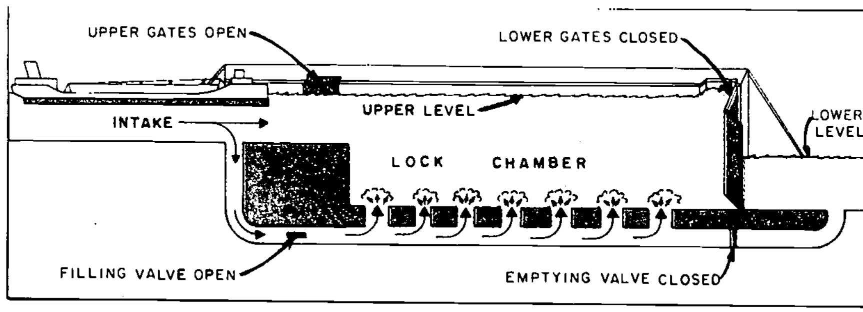
1. In a real situation, Carton A represents a lock in a lake whose water level is higher than water levels downstream.
2. Water flowing out of B would go into a river, lake, or ocean whose water level was lower than A. If A represents Lake Erie, for example, B represents Lake Ontario, and the water flowing out of B goes into the St. Lawrence River.
3. The emptying valve is open when the water level in a lock is being lowered and when ships are leaving the lock. The emptying valve is closed when the lock chamber is being filled for ships going upstream.
4. The filling valve is open when a lock chamber is being filled for ships going upstream. The filling valve is closed when the water level in the lock is being lowered for ships going downstream.
5. Gates open only when the water level in the lock is the same as the water level downstream.
6. They could make holes in the bottom of the cartons and connect them with tubing or plug them with stoppers. Unclamping the tube or removing the stopper would let the water move between chambers without opening the gates.

Backgrounder

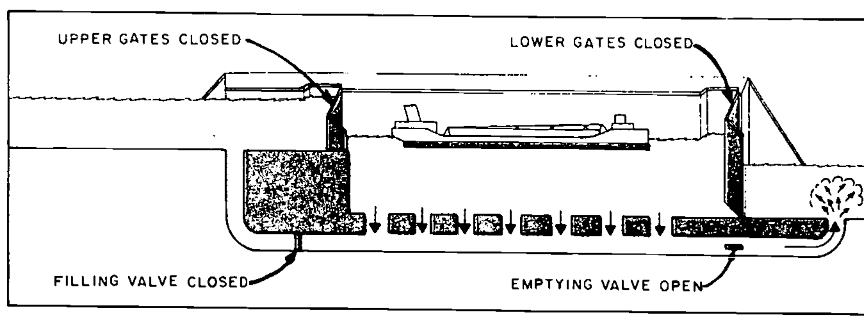
HOW NAVIGATIONAL LOCKS OPERATE

These diagrams show how a ship is lowered in a lock; a ship is raised by reversing the operation. No pumps are required; the water is merely allowed to seek its own level.

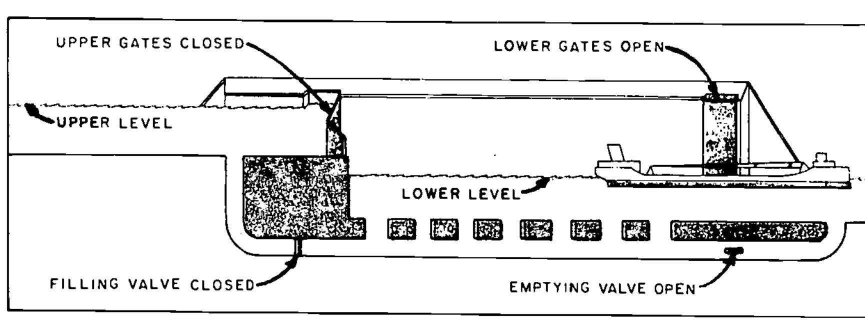
With both upper gates and lower gates closed, and with the emptying valve closed and the filling valve open, the lock chamber has been filled to the upper level. The upper gates have then been opened, allowing the ship to enter the lock chamber.



Now the ship is in the lock chamber. The upper gates and the filling valve have been closed, and the emptying valve has been opened to allow water to flow from the lock chamber to the lower level.



The water level in the lock chamber has gone down to the lower level, the lower gates have been opened, and the ship is leaving the lock chamber. After this, the lock is ready for an upbound ship to come in and be lifted, or may be filled (as above) to lower another downbound ship.



REVIEW QUESTION

Demonstrate your model to students in another class and explain how ships can go from the ocean to the higher elevations of the Great Lakes.

REFERENCES

Boyer, Dwight. 1977, *Ships and Men of the Great Lakes.* New York: Dodd, Mead & Company.

Bryant, Jeffery A., 1993. Condition of shipping on the Great Lakes. In: Fortner, R.W. and V.J. Mayer, eds. *The Great Lake Erie.* Columbus: Ohio Sea Grant.

Clary, James, 1985, Ladies of the Lakes. *Michigan Natural Resources Magazine.*

Coles Publishing Company Limited, 1980, *Adventures on the Great Lakes.* Toronto: Coles Publishing Company Limited.

LesStrang, Jacques, 1973, *The Great Lakes Ports of North America.* Michigan: The LesStrang Publishing Corporation.

Havinghurst, Walter, 1975, *The Long Ships Passing: The Story of the Great Lakes.* New York: Macmillan Publishing Co., Inc.

Great Lakes Shipping Today (Lake Carriers Association)
http://little.nhlink.net/wgm/lca/today.html

Great Lakes shipping schedules
http://www.acs.oakland.edu/~ncschult/boatnerd.html

Great Lakes Bookshelf (Harbor House Publishers)
http://www.harborhouse.com/bookshel.htm

Great Lakes buoy data
http://www.ems.psu.edu/wx/regions/greatlakes.html

Lake Carriers Association Web page
http://www.en.com/lcaships/

Maps
http://www.great-lakes.net:2200/ecosystem/tools/maps.html

U.S. Army Corps of Engineers
http://sparky.nce.usace.army.mil

How have ships and sailing influenced our language?

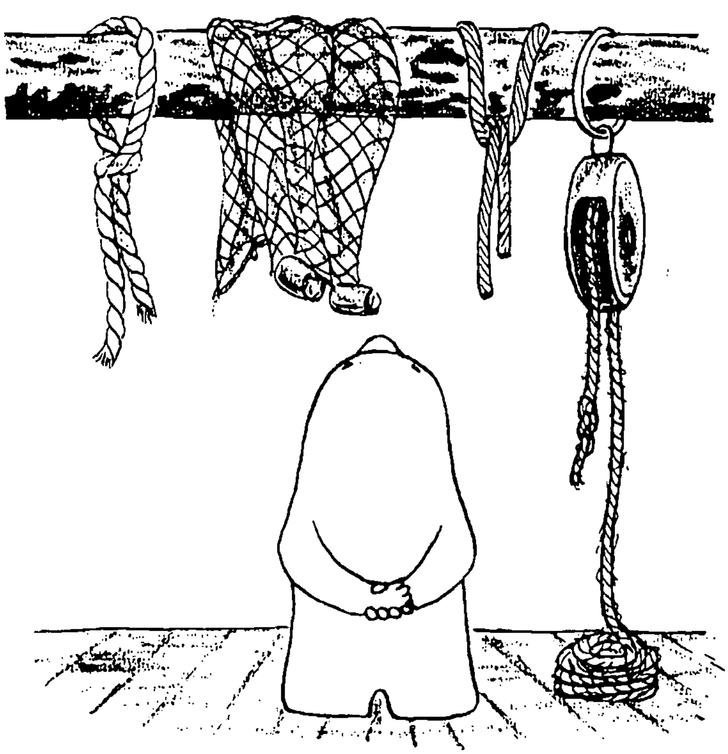
The life of sailors and the activities of ships have had a great influence on the cultural heritage of all seafaring nations. For example, some expressions the early sailors used are now a part of our everyday language. A person who "knows the ropes" today is an expert who knows what to do. In early sailing days, the new sailor usually did not know much about the ship's rigging. By the time his training voyage was over, though, his discharge papers could be marked "knows the ropes."

OBJECTIVE

When you have completed this activity you should be able to describe and give examples of the extent to which ships and sailing have influenced our language.

PROCEDURE

A. Engage your thinking on this subject by brainstorming with the class about common sayings that relate to fish, fishing, and the sea or water in general. Teams of students could challenge each other to come up with the most sayings, or your class could analyze what aspects of water have had the most influence on the language.



Source

OEAGLS EP-18C, *Knowing the Ropes,* by Rosanne W. Fortner and Victor J. Mayer.

Earth Systems Understandings

This activity is related to ESU 1, the way people express their feelings about Earth.

Materials

- Paper.
- Pencil.
- Drawing supplies.

Answers

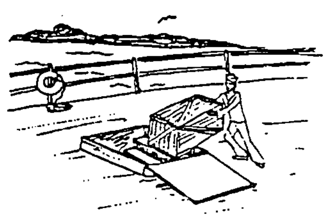
A. Offer some ideas to get this process started. People are called the names of sea animals that relate to their characteristics: old crab, shark, octopus, cold fish, a whale of a guy, etc. We speak of taking something hook, line, and sinker; fishing for answers, keeling over, being up the creek, or in over our heads. This is a fun and surprising exercise that shows how strongly our culture has related to water.

B. a. Down the hatch. Today's meaning: to take in food or drink.
   b. Making ends meet. Today this means getting by financially.
   c. Stand by. Today this means wait, usually until something else happens.
   d. Skyscraper. In modern language, this means a very tall building.

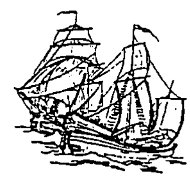
B. Below are some common expressions that had their beginnings at sea. Think about what each one might have referred to on an early sailing ship. Then try to match the saying with the picture that shows its meaning. Write a sentence about each picture to tell what the saying means in our modern language.

1. stand by
2. making ends meet
3. skyscraper
4. down the hatch

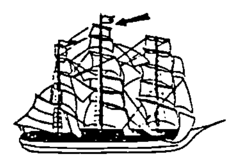
b.



a.



c.



d.

C. Some teachers have used these expressions in cooperative learning formats. They lend themselves to research on historical concepts and practices.

Students should enjoy drawing the pictures to illustrate these terms. Please be accepting of unique ideas and marginal artwork. The intent of this section is for students to visualize the setting for word origins.

C. Read the following paragraphs about the original meanings of some other common expressions. On a separate sheet of paper, draw a picture that shows the original meaning for at least one of the sayings.

1. The expression 'he let the cat out of the bag' today means that someone told something he shouldn't have told. Many years ago, this sentence would have brought fear in the person who had just done something wrong. Because of his wrongdoing, the cat-of-nine-tails was brought out of a canvas bag. The cat was made of nine pieces of rope, each about 18 inches long with three knots at the tip. Flogging, at the very least, would cause severe wounds. The U.S. Congress prohibited the use of the cat in 1850.

2. On board ship. a sailor's misdeeds were recorded daily, and punishment (flogging with the cat) was carried out on the following Monday. This is where we got the expression "blue Monday."

3. When sailors went ashore, they visited the seaport pubs frequently. When their money ran out, the bartenders gave them credit. A tally board was kept of the pints and quarts they consumed. The quartermaster of a ship would remind his crew to "mind their p's and q's," since this showed how much they'd been drinking.

4. Two expressions that are still used by mariners are log and knots. Sailors record information about their voyages in a daily "log," which is similar to a diary. These recorded journals got their name from the term "chiplog." A chiplog was a device used by sailing ships to measure speed in "knots." The device consists of a flat triangular piece of wood (5 inches on each side) with a long rope attached to the center. The "log" was thrown overboard to trail behind the ship. As the ship moved forward, the object pulled more and more rope overboard. Sailors could measure how much rope was trailing by keeping track of how many knots on the rope were pulled overboard in 28 seconds. The result is the rate of speed of the vessel, which was written as "knots." (Knots measure velocity in nautical miles per hour. One nautical mile is about 6,076 feet or 1,800 meters.)

D. The language of the sailors on the Great Lakes is different from that of "salty" sailors. All vessels on the lakes are called boats regardless of their size. The captain is not said to be "in command." He "sails the boat," while the chief engineer "runs the boat." Speed is measured in miles per hour, never in knots. A boat that can go more than about 12 miles per hour is a "slippery" boat that can pass up all the others.

In going through the lakes, cargo boats are "downbound" if heading toward the sea, and "upbound" if heading inland. In most lakes this is easy to remember, but in Lake Michigan, a steamer going to Chicago is upbound even though it is sailing to the south! In each lake below, draw arrows that point in the upbound direction.

Answers

Arrows in the upbound direction are shown above. Note that either direction is upbound in Lake Michigan, because boats going from Chicago to Duluth would be upbound, and one going to Chicago would also be upbound. There is considered to be only one upbound direction in the other lakes, however.

Review Questions

1. Make a list of at least five sayings that have come into the English language as a result of our heritage of ships, shipping, and working on the water.

2. Discuss the ways in which our language origins can get lost. Suggest ways in which young people can learn about old sayings and their origin.

Extensions

Develop and play a game of Scrabble® or other anagrams using only words that came from human activities or association with the water. Or, develop a crossword puzzle in which your friends must know what old shipping terms mean before they can solve the puzzle.

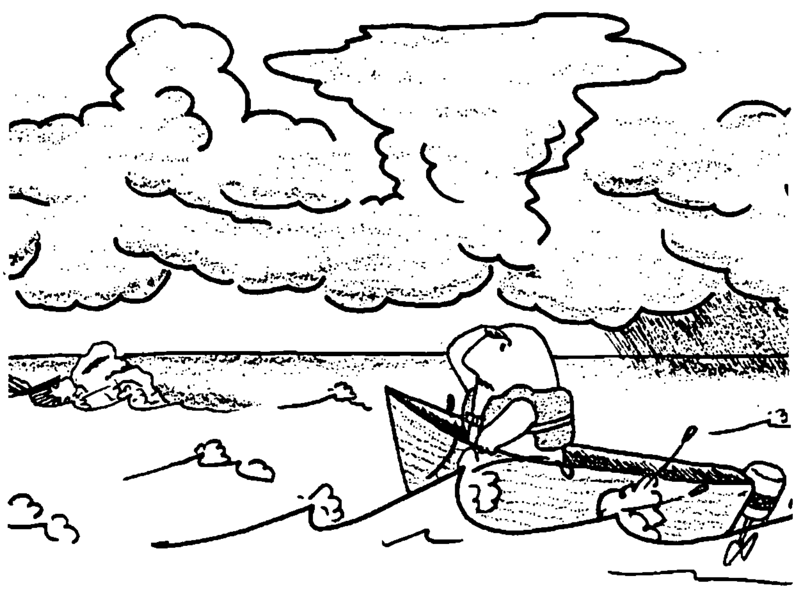
What is the Great Lakes Triangle?

In 1974, Charles Berlitz wrote in his famous best seller, *The Bermuda Triangle:*

> There is a section of the western Atlantic, off the southeast coast of the United States, forming what has been termed a triangle, extending from Bermuda in the north to southern Florida, and then east to a point through the Bahamas past Puerto Rico to about 40 degrees west longitude and then back again to Bermuda. This area occupies a disturbing and almost unbelievable place in the world's catalogue of unexplained mysteries. This is usually referred to as the Bermuda Triangle, where more than 1,000 lives have been lost in the past 26 years, without a single body or even a piece of wreckage from the vanishing planes or ships having been found.

Former aviator Jay Gourley has since written a book called *The Great Lakes Triangle* (1977), which claims that the Great Lakes account for more unexplained disappearances per unit area than the Bermuda Triangle. This is no small comparison, considering that the Bermuda Triangle is 16 times larger than the Great Lakes area. Gourley says:

> Because of the irregular shape of the Great Lakes, pilots — aware of the dangers within — ordinarily circumnavigate the lakes, even when overflying might be shorter. It is almost impossible for even the slowest aircraft to be more than 20 minutes from land. Today's airliner can cross Lake Erie through the middle in ten minutes. Faster aircraft can do it in much less than four minutes. Over any point on any of the Great Lakes it is possible for the pilot of any jet airliner to shut down all his engines and literally glide to land. There are hundreds of ground-based, sea-based and air-based radios constantly monitoring emergency frequencies for any sign of trouble.
>
> Aware of the curious incidents over the Great Lakes, the Federal Aviation Administration several years ago instituted a special "Lake Reporting Service;" pilots on Great Lakes overflights make continuous reports to ground stations. A 10-minute delay in such a report automatically launches a search-and-rescue operation. This service has saved many lives that would have been lost to ordinary accidents, but the high incidence of inexplicable disasters has remained unaffected.



Source

Activity A of OEAGLS EP-17, *The Great Lakes Triangle*, by Rosanne W. Fortner and Daniel W. Jax.

Earth Systems Understandings

This activity focuses on ESU 3, analysis of data and scientific habits of mind.

References

Berlitz, Charles. *The Bermuda Triangle.* New York: Doubleday and Company, 1974.

Gourley, Jay. *The Great Lakes Triangle.* New York: Aaron M. Priest, Inc., 1977.

Materials

Figure 1 and Table 1

Note:
Table 1 lists the disappearances or wrecks of ships and planes that are plotted in Figure 2. If students use only the figure, post the table where they can refer to it.

Answers

1. Areas with many disappearances include eastern Lake Superior, western Lake Erie, and areas around Milwaukee and Chicago.

2. Allow for guessing: the areas in Lake Michigan are around busy airports. Eastern Lake Superior has a narrow approach route into the St. Mary's River.

3. Accept all answers at this point. The idea here is to convince students that there are many science questions that require several hypotheses to be investigated at once. The interesting questions raised here are investigated in the next activity.

OBJECTIVE

When you have completed this activity you will be able to:

- Demonstrate an ability to perceive patterns in a set of data.
- Explain how scientific habits of mind should include the seeking of logical explanations for "mysterious" happenings.

PROCEDURE

Figure 2 shows the approximate last position of disappearing ships and planes in the area of the Great Lakes Triangle. Look at the map symbols and their locations to answer the questions about the map.

1. Are there some areas where large numbers of losses have occurred? Where?

2. What are some possible logical explanations for large numbers of losses having occurred at these particular areas?

3. Why do you think some of the planes, ships, and people were never found?

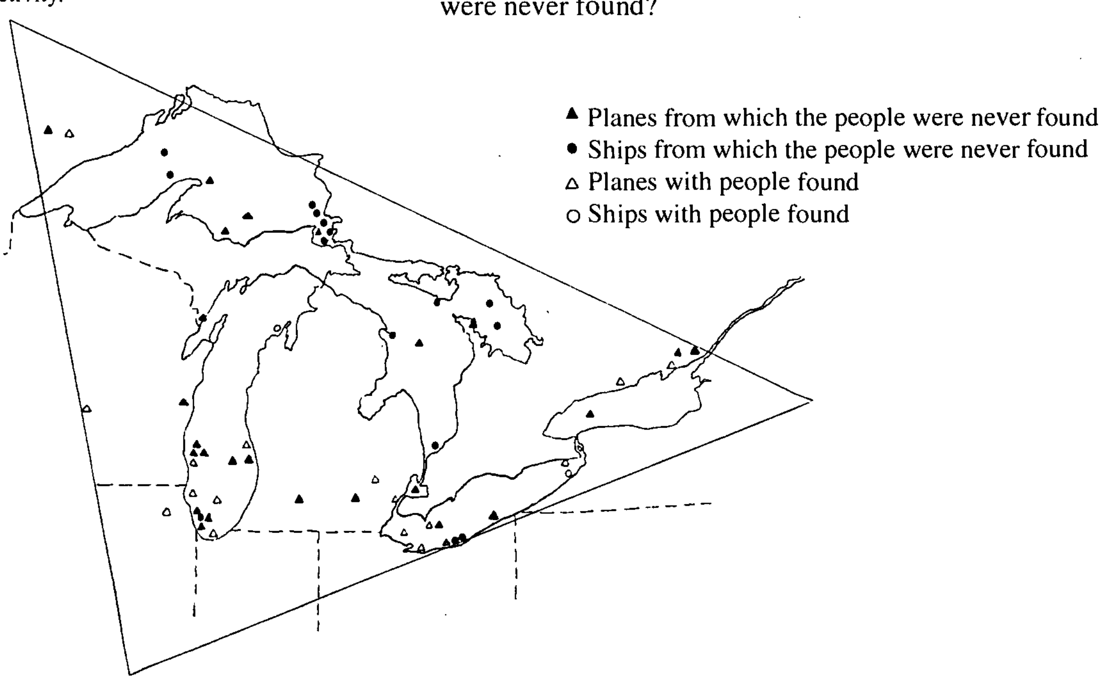


Figure 1. Estimated locations of disappearances described in Gourley's *The Great Lakes Triangle.*

Table 1. GREAT LAKES TRIANGLE DISAPPEARANCES

Date:	Craft	Location at Time of Disappearance	People Missing
10/28/1892	*Ostrich* wooden schooner	Off Manitou Island, Lake Superior	all
10/28/1892	*W.H. Gilcher* steel grain ship	West Straits of Mackinac, Lake Superior	all
8/20/1899	*Hunter Savidge* schooner	Lake Huron, near Alpena, Michigan	5
11/21/1902	*Bannockbum* small freighter	Middle of Lake Superior	all
10/09/07	*Cyprus* steel freighter	Off Coppermine Point, Lake Superior	all but 1
12/01/08	*D.M. Clemson* steamer	Lake Superior, near Soo Locks	all
11/12/13	*The Price* ship	Southern tip of Lake Huron	all (some bodies recovered)
11/26/13	*Rouse Simmons* schooner	Lake Michigan, just north of Chicago	17
11/24/18	*Inkerman* minesweeper	Lake Superior, near Soo Locks	all
11/24/18	*Cerisolles* minesweeper	Lake Superior, near Soo Locks	all
12/07/27	*Kamloops* steamer	Isle Royale	all
9/26/30	*Our Son* schooner	Straits of Manitou, Lake Michigan	0
11/21/36	*Hibou* passenger steamer	Georgian Bay	7
12/02/42	*Admiral* "a stout ship"	Lake Erie, 8 miles from Avon Point and 11 miles west of Cleveland	14
12/02/42	*Clevco* tanker barge	Lake Erie, 8 miles from Avon Point and 11 miles west of Cleveland	32 (some bodies recovered)
6/23/50	Northwest Airlines Flight 2501	70 miles east of South Haven, Michigan	58
12/18/50	*Sachem* tugboat	11 miles north of Dunkirk, New York	0
10/28/52	Small plane	35 miles northeast of Marquette, Michigan	4
11/28/52	CF-FUV Plane	Lake Superior, between Keweenaw Point and Whitefish Point	all
8/27/53	Jet	Over southern Lake Michigan	1
8/23/54	Twin jet interceptor	North shore of Lake Ontario, near Ajax, Ontario	0
6/8/55	Light plane	North of Lake Superior, between Kapukasing and Kenora, Ontario	0
5/15/56	Canadian twin jet	Just northeast of Lake Ontario	all
8/2/56	CF-100	Bruce Peninsula, near Georgian Bay	2
12/8/56	Aero commander	North shore of Lake Erie, near Buffalo	0
5/21/59	Piper PA-18	Lake Superior, near Teggan Lake, Ontario	2
12/16/59	Aero Design 560E	Lake St. Clair	2
9/23/60	Cessna 140	Over Lake Michigan, just south of Milwaukee	0
9/27/60	Twin Jet interceptor	Lake Ontario	1
11/29/60	Piper plane	Lake Michigan, just off Chicago	3
3/26/61	Small plane	Wisconsin, just west of Lake Michigan	all

7/20/62	Light plane	Over western end of Lake Erie, between Alliance, Ohio, and Detroit, Michigan	0
2/12/63	Small plane	Over Niagara Falls	0
9/9/63	Light plane	Sandusky, Ohio	0
2/15/64	Twin engine plane	Western Basin, Lake Erie, between Detroit, Michigan, and Akron, Ohio	2
9/6/64	Twin engine Piper	Markham, Illinois	0
3/20/65	Cessna 170B	Lake Michigan, near Chicago	1
8/4/65	Mong sport plane	Lake Michigan	0
3/17/66	Twin engine Poper	Lake Huron, between Wiarton, Ontario, and Alpena, Michigan	1
12/19/66	Light plane	Over water between Cleveland, Ohio, and Erie, Pennsylvania	1
12/19/66	Cessna 172	Lake Erie, near Ashtabula	all
1/14/67	Plane	Lake Michigan, near Muskegon	3
12/10/67	Multi-engine Beech 18	Lake Monona, near Madison, Wisconsin	0
5/21/69	Beech 35	Northwest shore of Lake Michigan, near Menominee, Michigan	4
6/17/69	Piper PA-28	Lake Michigan, 15 miles east of Milwaukee	0
11/6/69	Twin turbojet	Lake Michigan, 15 miles east of Milwaukee	7
4/4/70	Beech 36	Lake Michigan, near Gary, Indiana	0
6/12/71	Cessna 180	10 miles north of Whitmore Lake, Michigan	0
7/21/72	Twin Piper PA-31	Lake Michigan, 15 miles east of Milwaukee	1
7/21/72	Piper plane	Lake Michigan, just off Milwaukee	1
11/30/72	Beech Expeditor	Lake Michigan, between Detroit and Milwaukee	1
12/4/72	Cessna 320	Eastern shore of Lake Michigan	0
12/7/72	Plane	Lake Michigan, between Milwaukee and Chicago	1
12/15/72	Lear jet	Just south of Detroit, Michigan	0
3/20/73	Beech F18S	Lake Erie, between Cleveland and Detroit	1
4/20/73	Lake Seaplane	Lake Erie, just east of Howell, Michigan	1
4/19/74	Helicopter	Near northeast shore of Lake Ontario between Ottawa and Greenville, Michigan	0
11/10/75	*Edmund Fitzgerald*	Lake Superior, off Coppermine Point	29
11/22/79	*Waubuno* steamer	Lake Huron, Georgian Bay	24
11/25/81	*Jane Miller* passenger steamer	Colpoys Bay, near Georgian Bay	28

How can disappearances within the Triangle be explained?

Science is a process for finding answers to questions and solving mysteries. This investigation includes three activities leading to a consideration of fact and speculation about the disappearances of planes and ships in the Great Lakes Area. The activities are an example of how scientists work, and they can serve as a practical application of your Earth systems knowledge and skills as well.

Your class should first study the locations of missing craft and personnel in the activity titled, "What is the Great Lakes Triangle?" Like scientists, you should examine the data for trends and indicators; in this case you examine concentrations of the disappearances and speculate on their causes.

The present investigation is actually three activities that are to be performed by different classroom groups simultaneously through cooperative learning. If time permits, all three activities could be done by the entire class. The activities treat the wreck of the *Edmund Fitzgerald* as example of a Great Lakes Triangle tragedy. When all three topics have been considered, there will be a discussion to consider whether the wreck of the *Edmund Fitzgerald* was an accident resulting from natural causes or whether other supernatural or extraterrestrial forces might be at work (as proposed in Berlitz' *The Bermuda Triangle).*

OBJECTIVES

Upon completion of this investigation you should be able to:

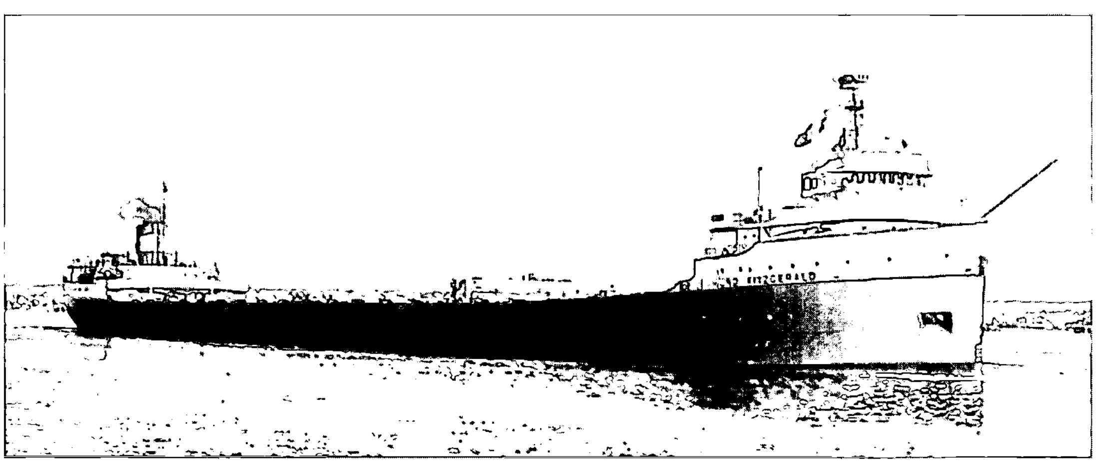
- Discuss the values of using several data types and sources to solve a science problem.
- Demonstrate how bathymetric charts are used and constructed.
- Demonstrate how weather information is mapped and interpreted.
- Give an example of how scientists use multiple working hypotheses to solve complex problems.

Source

Activity B of OEAGLS EP-17, *The Great Lakes Triangle,* by Rosanne W. Fortner and Daniel W. Jax.

Earth Systems Understandings

This investigation focuses on ESU 3 and 4, with data analysis related to interacting subsystems. ESU 7, careers, is also introduced.



One of the last photographs taken of the *Edmund Fitzgerald.*

PROCEDURE

Materials

- Navigational chart of eastern Lake Superior, #14962.
- Cardboard tube 45-55 cm long.
- Dry beans, rice or aquarium gravel.
- Transparencies of outline maps of Lake Superior.
- Transparencies of weather maps.
- Pencil or pen.
- Blank transparency.
- Washable markers.
- Tape.

Your expert group will be assigned to investigate one of the following hypotheses:

1. Great Lakes bulk carrier design could be responsible for the wreck of the *Edmund Fitzgerald.*

2. The severe lake storm was responsible for the wreck of the *Edmund Fitzgerald.*

3. Lake bottom features (either unknown or unavoidable) were responsible for the wreck of the *Edmund Fitzgerald.*

After your investigations have been completed, your teacher will conduct a class discussion. Findings from all three topics will be brought together. The discussion will help you answer the questions below. It may be helpful to read the questions before you begin work, but do not try to answer them until all the investigations have been completed and reported.

1. Could ship design be responsible for the loss of some vessels?

2. How bad is a severe storm on the Great Lakes in terms of wind speeds, wave heights, duration (how long the storm lasts), and visibility?

3. What kinds of areas in lakes and oceans may be safer when a storm is in progress?

4. How are bathymetric measurements made and interpreted?

5. Is it possible that there are features on lake and ocean bottoms that mariners don't know about?

6. Consider the *Edmund Fitzgerald* as an example of a Great Lakes Triangle disaster. Are there natural forces that could explain the sinking? What are some possible explanations?

7. Considering the storm, the water depth and temperature, and what possibly happened to the *Fitzgerald*, why do you think the bodies of the crewmen were never found?

Hypothesis 1: Great Lakes bulk carrier design could be responsible for the wreck of the Fitzgerald.

INTRODUCTION

The *Edmund Fitzgerald* sank in the Great Lakes Triangle area on November 10, 1975. The Coast Guard and the National Transportation Safety Board both decided that the wreck was caused by a hatch cover that let water enter the hold. If you examine the general shape and parts of the *Fitzgerald*, you may be able to point out to your classmates some ways that ship design could have been at least an important factor in the sinking.

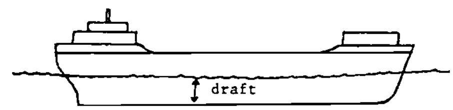


Figure 1. Draft of a vessel.

The ships that carry iron ore (taconite pellets) on the Great Lakes are designed to haul huge loads with very little draft. *Draft* is the depth of water necessary to float a vessel. If a ship "draws" (has a draft of) 30 feet, it can only go in water that is more than 30 feet deep. Because of underwater rocks and the need to go through locks from one lake to another, most lake vessels draw 25 feet or less when fully loaded. This means that a large load must be spread out in a thin layer. If a ship is designed for use on one lake only, it can have a larger draft, because it doesn't have to go through any locks.

A bulk carrier is a ship that carries a large amount of unpackaged material like grain or minerals. Great Lakes bulk carriers are usually about 10 times as long as they are wide. The *Edmund Fitzgerald* was the biggest ore carrier on the lakes when she entered service in 1958. The *Fitzgerald* was 727 feet long, 75 feet wide, and drew (had a draft of) 25 feet of water.

PROCEDURE

Materials

- Cardboard tube at least 45 cm long.
- Tape.
- Dry beans, rice, or aquarium gravel.
- Marking pen.

A scale model is a small version of anything, with all sizes cut down by the same proportion. Architects, car designers, and such make scale models to see how a product is going to look before they invest in the real thing. The model of a 30 x 20 meter house might be 3 x 2 meters, or 30 x 20 centimeters. For each of the model sizes given, the original measurements have both been divided by a certain number.

1. Build a scale model of the *Edmund Fitzgerald* using the dimensions given in paragraph 1 above. Use a cardboard tube that you flatten on one side to form the deck. Draw hatch

covers on the deck and outline the positions of other deck structures.

2. Seal one end of the "hull" with tape and pour beans, rice, or aquarium gravel into the hold until it is about three-fourths full. Seal the open end so that none of the "ore" can get out.

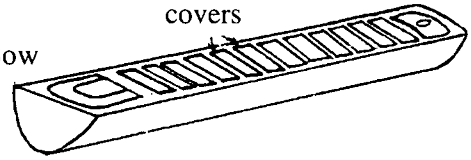


Figure 2. Example of a constructed scale model of an ore carrier.

This simulates the cargo of an ore carrier like the *Fitzgerald*. The hold of the ship is not really a single open chamber. It has dividers or "bulkheads" to separate one section from another. The *Fitzgerald* had three compartments for cargo inside its hold. Ore pellets were loaded through the hatches on deck.

3. Experiment with your model to find the answers to the following questions.

   A. Balance the model on the side of a pencil. What do you have to do to find the balancing point (center of gravity)?

   B. Suppose the ore is loaded and the ship is balanced for its trip across the lake. A storm comes up. Wind and high waves cause the ship to <u>roll</u> (rock from side to side) and <u>pitch</u> (rock from end to end). Which motion, roll or pitch, is more likely to shift the cargo out of balance?

   C. Waves break over the ship one after another. The water from one wave doesn't even clear the deck before more water piles on. How could this affect the ship's balance?

   D. A hatchway caves in or comes unsealed, letting water enter the hold. How could this affect the ship's balance?

   E. A series of waves raises up the stern and rolls under the ship toward the bow. If the cargo shifted strongly toward the bow, what could happen to the ship?

   F. The *Fitzgerald* was 727 feet long. She sank in 530 feet of water. What could happen to the ship if it suddenly took a nosedive to the bottom?

4. Prepare to explain to the class how ship design could be at least partly responsible for the loss of some vessels.

5. Share with the class the meaning of these terms: draft, scale model, hull, bulkheads, center of gravity, pitch, and roll.

Hypothesis 2: The storm was responsible for the wreck of the *Fitzgerald*.

INTRODUCTION

Weather conditions on the water can sometimes create freak accidents that appear to be more supernatural than natural. Sightings of "ghost ships," sea monsters, and the like often occur during periods of unusual weather. Natural forces and a good imagination are probably responsible for many of the unexplained phenomena of the Great Lakes and Bermuda Triangles.

The mariners of the world's oceans and the Great Lakes are always watchful of the weather. Their lives depend on how prepared they are for conditions on the water. Regardless of their preparedness, however, accidents happen. A storm may build up far more strength than weather predictions forecast, and the tremendous force of a raging sea may be more than a ship can take. Such an accident occurred on November 10, 1975, with the sinking of the ore freighter *Edmund Fitzgerald.*

PROCEDURE

Every six hours, at 1 P.M. and 7 P.M. and 1 A.M. and 7 A.M. Eastern Standard Time, observers all over the world report weather conditions at their location. Wind speed and direction are noted. Precipitation for the previous six hours is measured. Temperature, visibility and any other weather conditions are also recorded. The information is then put into an international code, sent to collection centers within each country and exchanged internationally. In this country, the information is collected and analyzed by the U.S. Weather Bureau.

At the centers receiving the coded weather information, weather maps are prepared. The messages are decoded, and the conditions reported are translated into figures and symbols. These are grouped around a small circle drawn on a map at the position of the station reporting the information. The circle on the map, with the figures and symbols describing the weather conditions at that location, is called a station model. The method of construction of a station model and an interpretation of its information are shown in Figures 3 - 5.

Materials

- Transparencies of Lake Superior.
- Wax pencils or washable markers.
- Overhead projector.

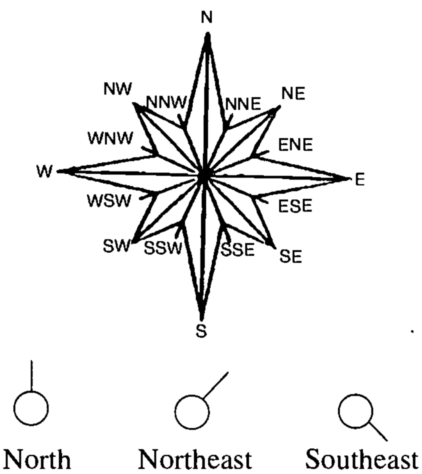


Figure 3. Method for showing wind direction. Circle is placed at location of station, and bar points to where wind is coming from.

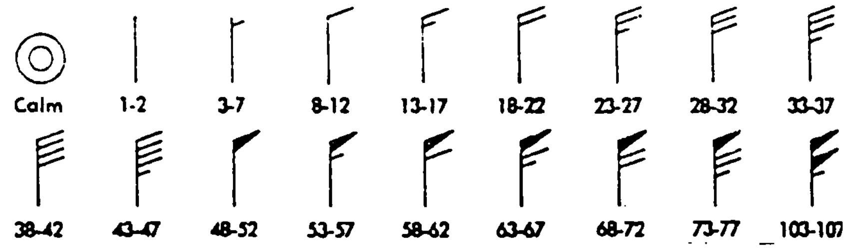


Figure 4. Symbols used to indicate wind speed (in knots).

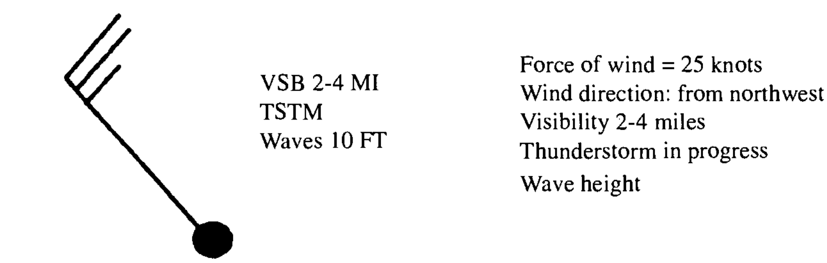


Figure 5. Interpretation of a Station Model.

You are to examine and report data (information) on weather conditions during the storm that caused the *Fitzgerald's* sinking.

Figures 6 and 7 show the weather data for 1 A.M. and 7 A.M. (Eastern Standard Time) on November 10, 1975. The abbreviations used stand for ships that reported in as weather stations. This information was taken from the actual transcripts of hearings following the sinking of the *Fitzgerald.* Look carefully at Figures 6 and 7. Notice how the low pressure center is moving and where the *Fitzgerald* (FTZ) is at each time.

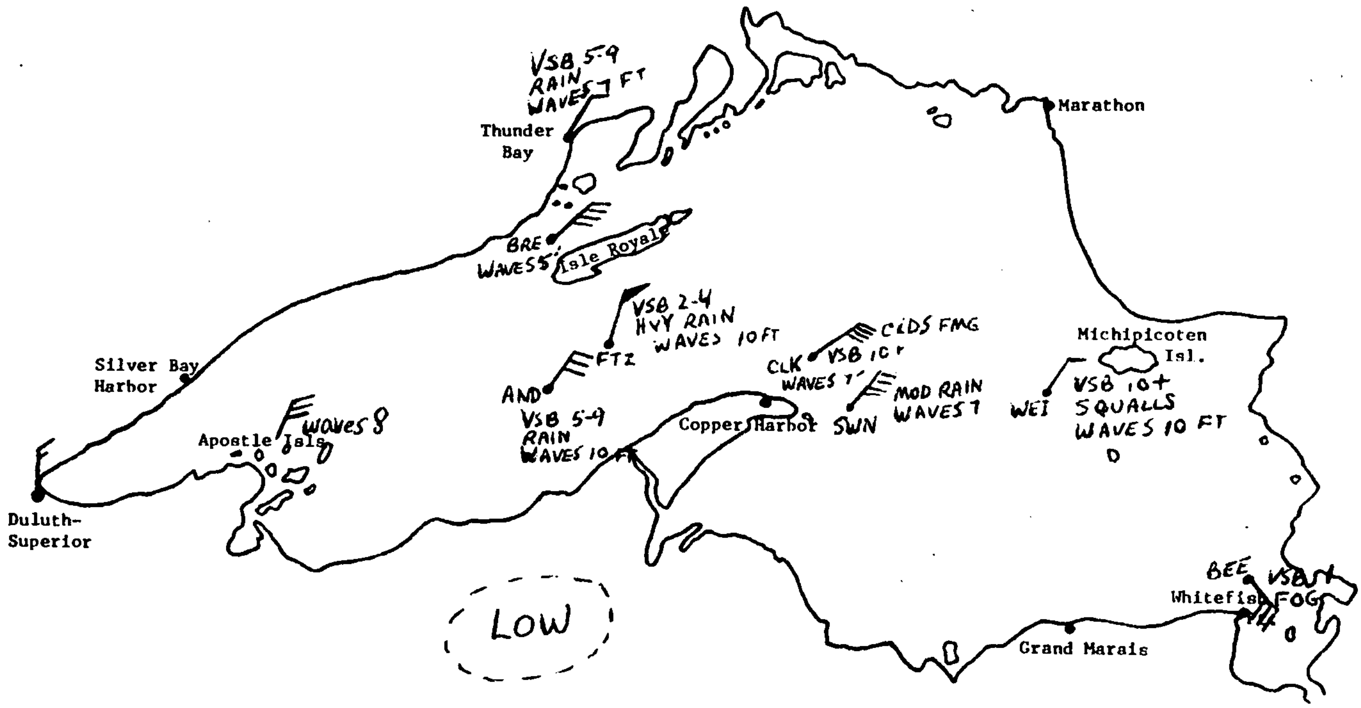
Divide your group in half. Each subgroup gets one transparency of Lake Superior (Map 3 or 4) and records on it the following information, as was done in Maps 1 and 2.

A. Date and time (plot a new map for each different time).

B. Wind, wave, precipitation, and visibility data for the stations listed. (Some stations are on land; others are reports from ships at the positions given.) The information to be plotted is listed for Maps 3 and 4.

MAP 1

Date: 10 November 1975
Time: 0100E

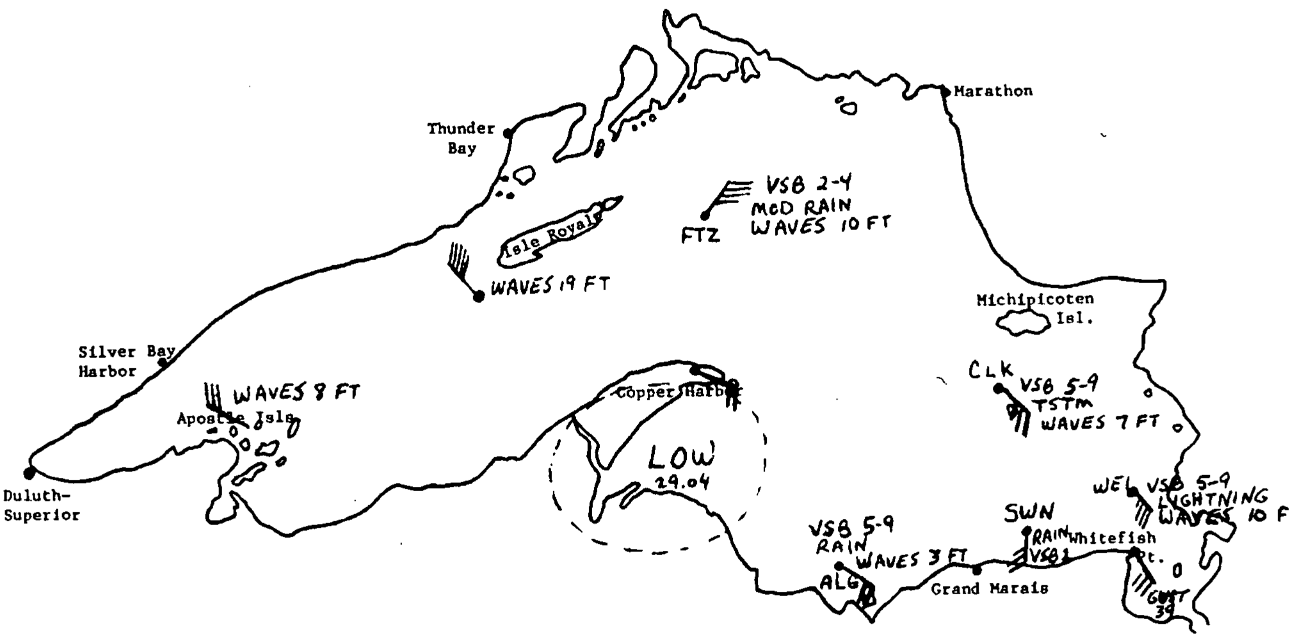


Location	Wind Speed (knots)	Wind Direction	Wave Height (feet)	Precipitation	Visibility (miles)
Anderson (AND)	32	NE	10	Rain	5-9
Fitzgerald (FTZ)	52	NNE	10	Heavy rain	2-4
Duluth	15	N			
Apostle Isls.	30	NNE			
Thunder Bay	10	NE	8	Rain	5-9
BRE	38	NE	7		
CLK	42	ENE	5	Clouds forming	10+
SWN	40	NE	7	Moderate rain	
WEI	30	NE	7	Squalls	10+
BEE	30	SE	10	Fog	1

Figure 6. Weather data from 1 A.M., November 10, 1975.

Map 2

Date: 10 November 1975
Time: 0700E



Location	Wind Speed (knots)	Wind Direction	Wave Height (feet)	Percipitation	Visibility (miles)
FTZ	35	NE	10	Moderate rain	2-4
Apostle Isls.	30	WNW	8		
WS of Isle Royale	45	NW	19		
Copper Harbor	20	ESE	6		
ALG	20	SE	3.	Intermit. rain	5-9
CLK	26	SE	7	TSTM	5-9
SWN	25	S		Rain	1
WEI	35	SE	10	Lightning	5-9
Whitefish point	30 gust 39	SE			

Figure 7. Weather data from 7 A.M., November 10, 1975.

WEATHER DATA FOR MAPS 3 AND 4 (TRANSPARENCIES)

MAP 3

Date: 10 November 1975
Time: 1300E

Location	Wind Speed (knots)	Wind Direction	Wave Height (feet)	Precipitation	Visibility (miles)
AND	20	SE	10	Clouds forming	10-24
Duluth	25	NW			
Silver Bay	20	NW	5	Clds. dissolving	10-24
SW of Isle Royale	40	WNW	10		
BEE	49	NW	7	Moderate snow	1
TAD	53	NW	15	Heavy snow	1/2
Copper Harbor	60	WNW	8		
Slate Island	25	NNW	7		
SIM	44	W	7		10-24
Caribou Island	40	WW	6		
CLK	41	S	13	Moderate TSTM	5-9
Whitefish Point	20	SW	15	Light snow	2-4

MAP 4

Date: 10 November 1975
Time: 1900E

Location	Wind Speed (knots)	Wind Direction	Wave Height (feet)	Precipitation	Visibility (miles)
Duluth	10	WNW			
Copper Harbor	40	NW	10		
Grand Marais	55	WW	13		
ARM	25	NW	8	Clds. dissolving	10+
NE of Isle Royale	40	NWW	5		
off Marathon	25	NW	5		
FTZ (sank)	49	NW	16	Drizzle & snow	10+

When both maps are finished, bring your group back together. Answer the following questions based on the sequence of maps 1-4.

1. In what direction was the storm moving? (Note the movement of the low pressure center.)

2. Do the winds around a low pressure center blow clockwise or counter-clockwise? Toward or away from the center? Are wind speeds greater or less as they get closer to the low pressure center?

3. On weather maps 1-4, check the station models for coastal weather and mid-lake weather. Which areas, coastal or mid-lake, had higher wind and waves?

4. Which areas had higher wind and waves, island areas or mid-lake areas?

5. Which side of the lake, Canadian or U.S., had more severe weather conditions?

The map below shows the courses taken by the *Fitzgerald* and a following ship, the *Anderson*.

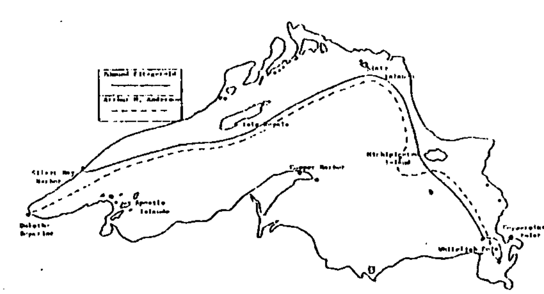
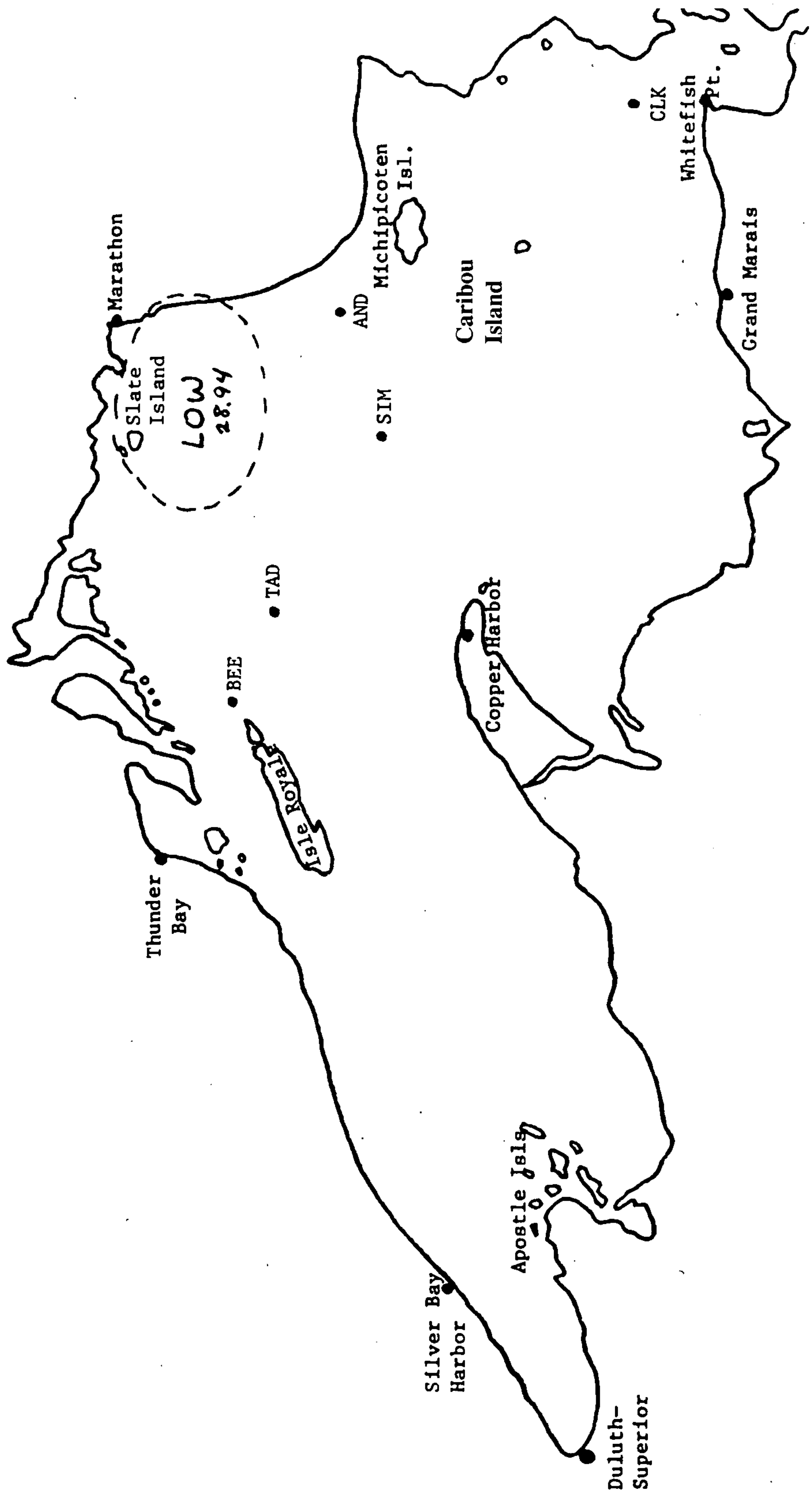


Figure 8. Courses steered by the *Arthur M. Anderson* (AND) and the *Edmund Fitzgerald* (FTZ) on the night of November 10, 1975.

6. Was this the best possible course in view of the weather conditions?

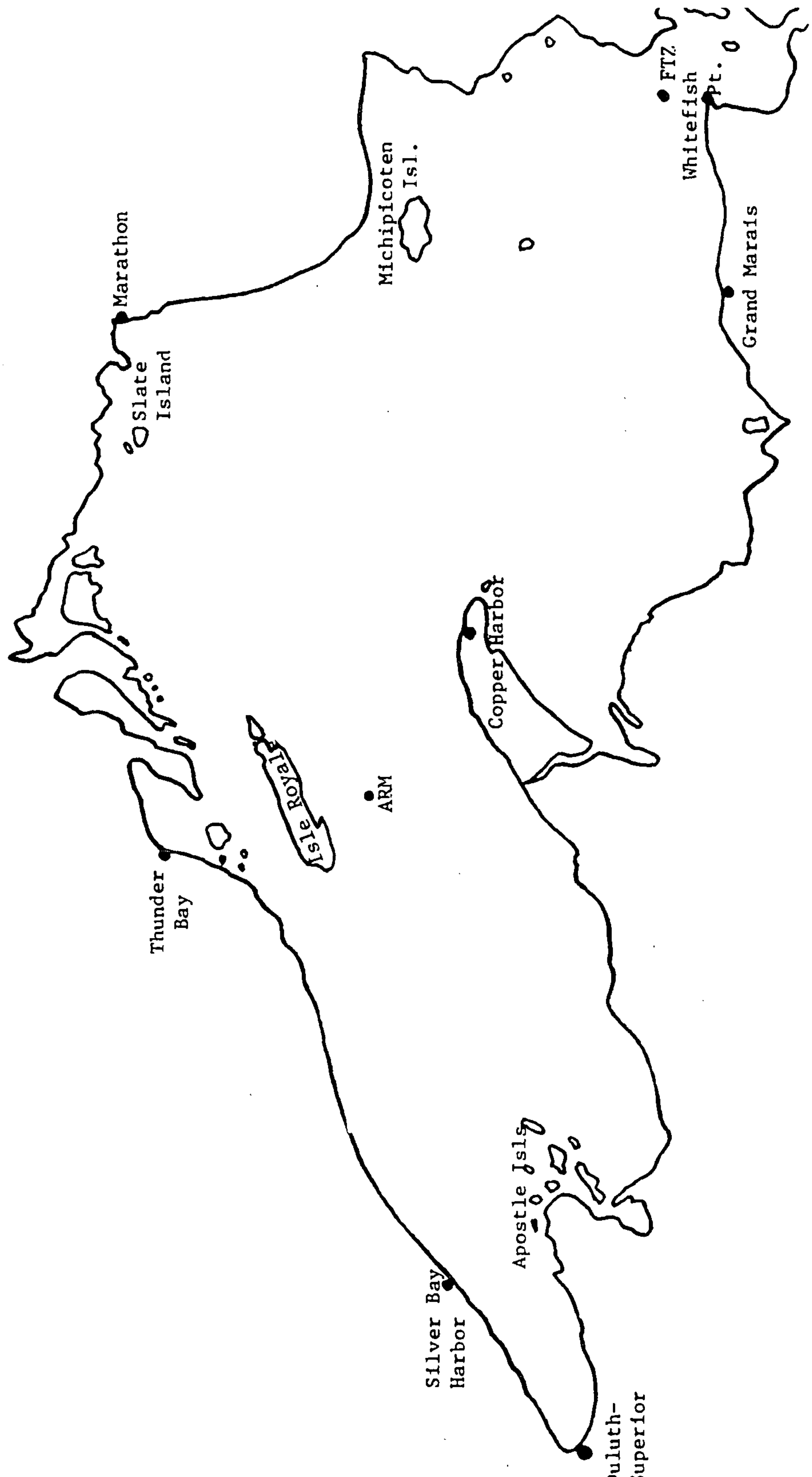
7. Plot a recommended course for the *Fitzgerald* on a third transparency. You will want to consider the storm's path, the wave heights, and wind speeds along the way. Be prepared to defend your choices for the rest of the class.



Map 3
Date:
Time:

60

59

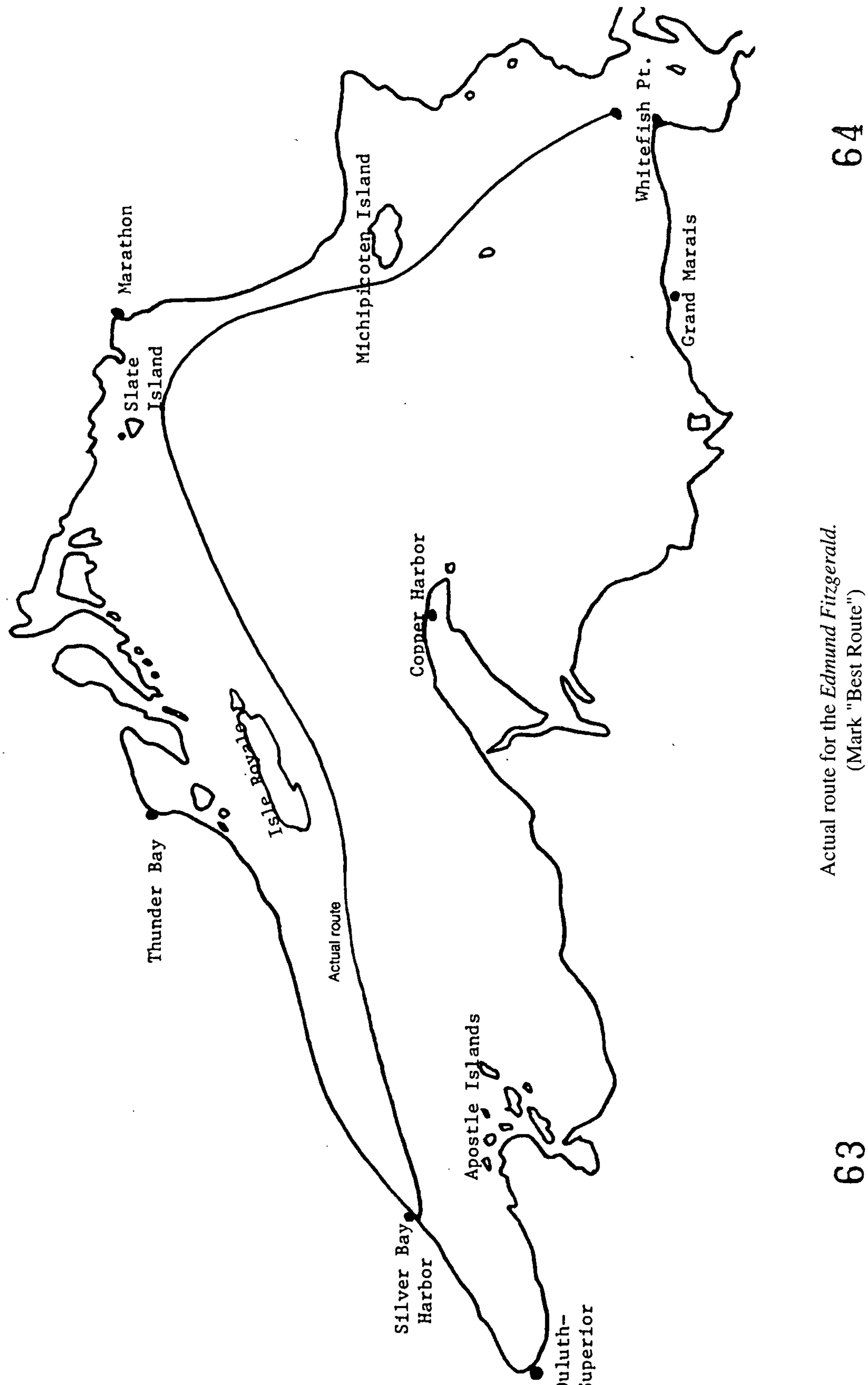


62

Map 4
Date:
Time:

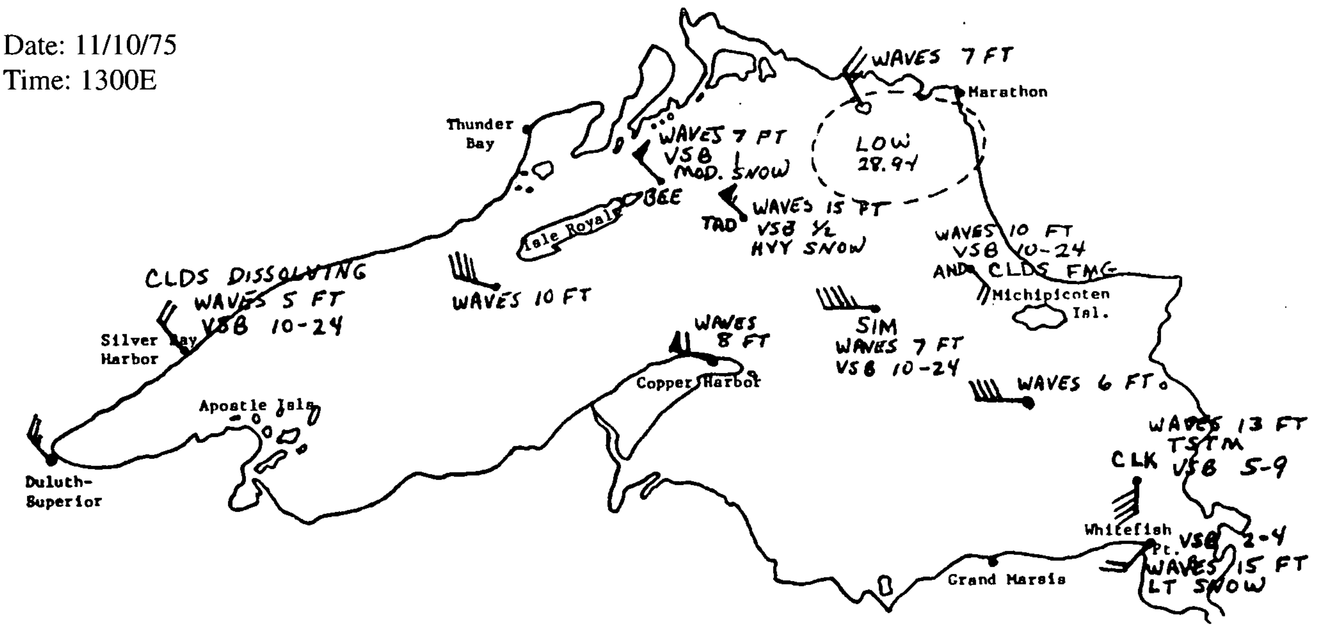
61

Map 5

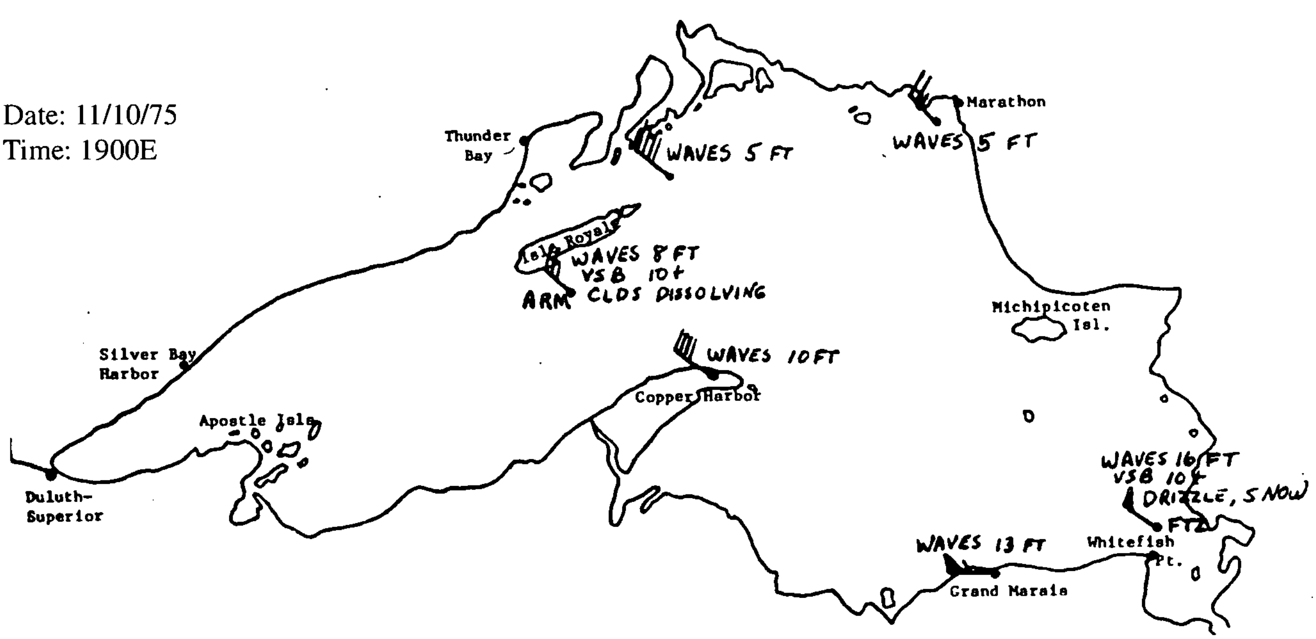


Actual route for the *Edmund Fitzgerald.*
(Mark "Best Route")

Date: 11/10/75
Time: 1300E



Date: 11/10/75
Time: 1900E



To the Teacher: Correct station models for students' map 3-4.

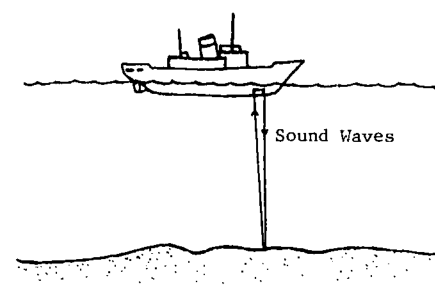
Hypothesis 3: Lake bottom features were responsible for the wreck of the *Fitzgerald.*

INTRODUCTION

How deep is the water? Every mariner must be aware of water depth in order to know if his or her vessel will float without bumping the bottom.

Exploring water depths began with crude lead-weighted ropes on wires lowered from ships. Knots or marks on these sounding lines were recorded as depth measurements. "Mark Twain," for example, meant that the water came up to the second mark on the line and was two fathoms (about 4 meters) deep.

In World War I, the echo sounder was developed. A sound sent out from an instrument aboard a ship bounces off the sea floor or lake bottom. SONAR (SOund Navigation And Ranging) uses the same principle. When the echo returns to the ship, depth is calculated. Sound waves travel through water at a speed of 5,000 feet per second. If the sound takes 1 second to reach the bottom, its echo takes 1 second to return and the water is 5,000 feet deep. Using the results of echo sounding, scientists can draw a bathymetric chart. ("Bathy" means deep, and "metric" means measured.) Such a chart shows the characteristics of the sea floor or lake bottom.



A ship using an echo sounder.

PROCEDURE

A contour line is a line connecting points of equal elevation or depth. We can construct bathymetric contours in the following way.

The numbers on the nautical chart are the soundings at various locations in a small lake. The larger the numbers are, the deeper the water. The zeroes indicate shoreline areas, where the water depth becomes zero. All the zeroes around the edge of the map have been connected to show the shape of the lake.

1. Are there other zeroes besides the lakeshore ones? What kind of a feature has been drawn at Point A?

2. Now find a line that roughly shows where the water is 50 feet deep. (U.S. mapmakers do not use the metric system to any great extent yet.) The line goes between the numbers

Materials

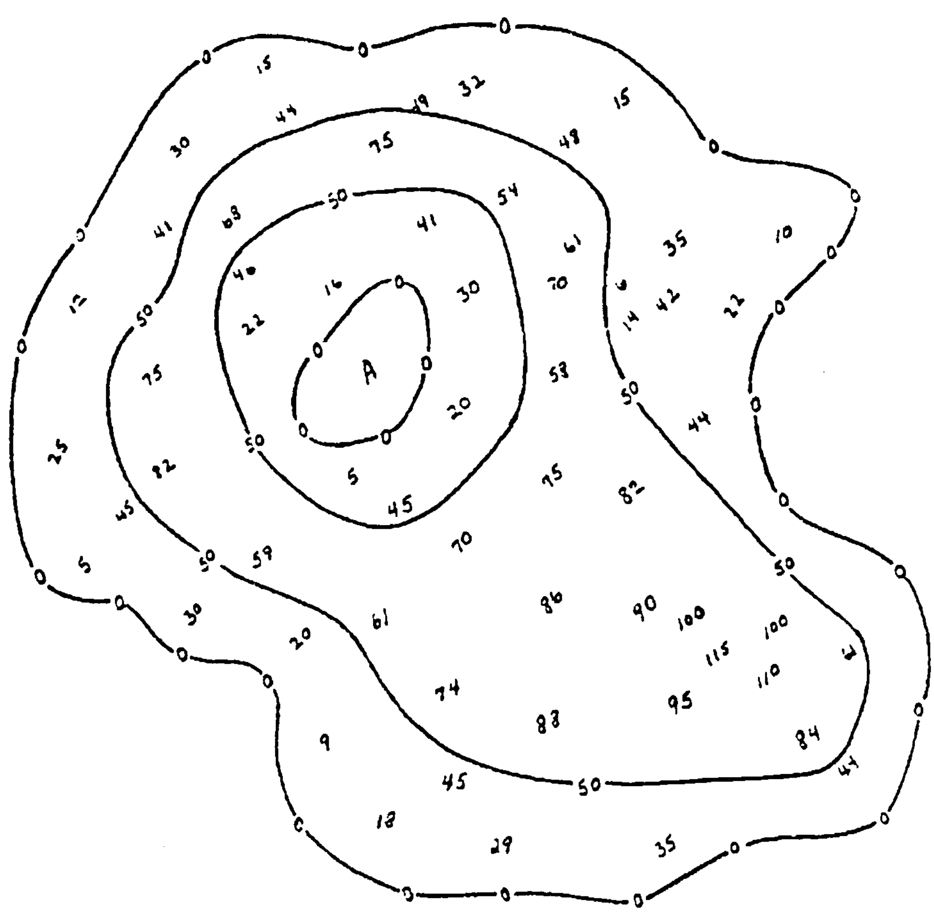
- Nautical chart of eastern Lake Superior (St. Mary's to Au Sable Point).
- Transparent sheet.
- Wax pencil or washable marker.

greater than 50 and the numbers less than 50. Contour lines do not end unless they go of the edge of the map, so the ends of the 50-foot line are connected.

There are two 50-foot bathymetric contours for this map. One surrounds the feature at A and another is around the inside of the entire lake. Be sure you understand why these lines were drawn where they are.

3. Put a Y on a part of the lake that has some very shallow areas close to the 50-foot line. This is a place where there is a rocky area or a shoal underwater. Sailors would have to be very careful not to bump their boats into this.

4. Draw a 100-foot contour line in the lake. Put an X on the deepest point in the lake.



Practice Map: Soundings in a Small Lake.

5. On the nautical chart showing the eastern end of Lake Superior, place a transparent sheet so that its short bottom edge is on the line labeled 46°50' and the long left hand edge is on the 85°00' line of longitude. Trace the shoreline onto your paper.

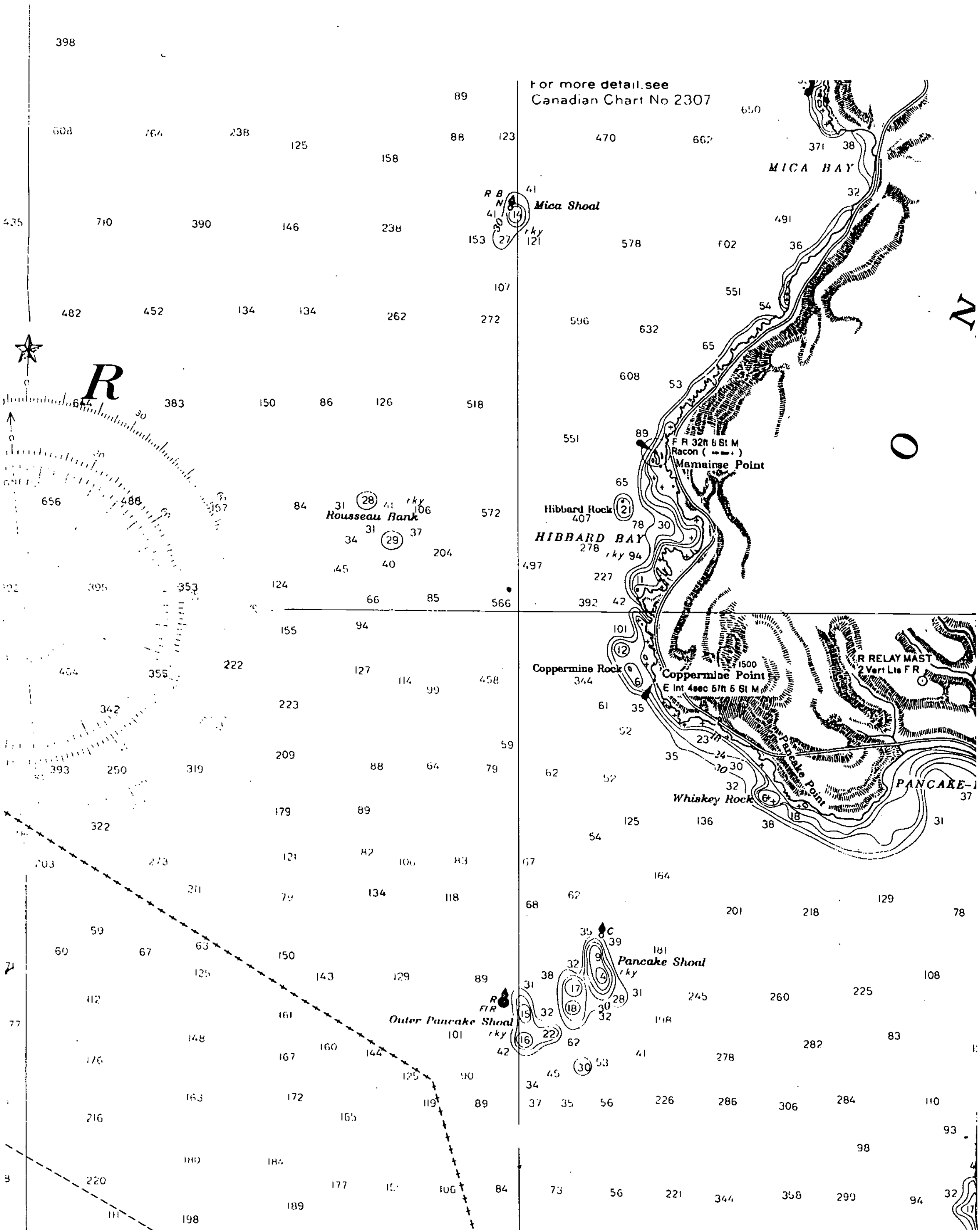
Note: The critical section of this chart is reproduced on the following page if a complete chart is not available.

6. In the area covered by the tracing paper, draw 50-foot bathymetric contours. Be sure to look around for the depths far out in the water that may need to be enclosed in such lines. (Contour lines cannot cross each other. Why?)

7. Also draw a 75-foot contour. Your map should now show places of shallow water that are surrounded by very deep water.

8. Label the town of Coppermine Point on your transparency. On November 10, 1975, the *Edmund Fitzgerald* sank off Coppermine Point in 530 feet of water. The ship was coming from the northwest. Put an X on the place where the sinking probably occurred.

9. The *Fitzgerald's* hull was 37 feet deep. In a storm with large waves, the hull might dip down to a depth of about 50 feet. Locate areas where hidden shoals might be (depth of 50 feet or less, and areas where few depth measurements have been made). Be prepared to show the class where the *Fitzgerald* could have struck bottom.


For more detail see
Canadian Chart No 2307
MICA BAY
Mica Shoal
F R 32ft 6 St M
Mamainse Point
Hibbard Rock
HIBBARD BAY
Rousseau Bank
Coppermine Rock
Coppermine Point
E Int 4sec 67ft 6 St M
R RELAY MAST
2 Vert Lts F R
Pancake Point
Whiskey Rock
Pancake Shoal
Outer Pancake Shoal
O
N

Base Group Leader's Guide

The following sequence is recommended for bringing out the major points (topics are addressed as if they were done by separate teams):

Leader
We have noted that many ships and planes have disappeared in the Great Lakes area. Does this indicate that some unusual forces are at work in the area, causing vessels and people to vanish into thin air, or could natural causes explain the losses? (No pause for answer.) Let's examine some things that might cause a ship to sink in the Great Lakes. Team 1, show us what you discovered about the balance of such a ship.

Team 1
Presents a model of the *Fitzgerald.* They explain what a scale model is and tell what is meant by draft of a ship.

Leader
When you experimented with your model, Team 1, show us what you discovered about the balance of such a ship.

Team 1
Tells what was done with the model and how they answered questions A to F.

Team 1 Answers

A. Cargo must be positioned exactly right to balance the ship.

B. Pitch will shift the cargo out of balance more.

C. Waves pile up water on deck and weight the ship down more. (They could also cause it to have a greater draft temporarily, so it could strike an obstacle underwater.)

D. Water sloshes as the ship rolls and pitches. The water makes the cargo shifting even more likely.

E. The ship could dive to the bottom.

F. It could snap into pieces or the front part could be buried in the lake bottom.

Leader
(Show picture of *Fitzgerald* wreck, Figure 9.) Could this have happened in the way you described? (Answer depends on Team 1's previous answers.) If E and F were well considered, answers here should be "yes."

Leader
Team 2 has investigated the weather conditions on the day the *Fitzgerald* sank. Team 2, please explain when and how a station model is constructed.

Team 2
Gives the requested information from its activity.

Leader
What was the weather like on November 10, 1975?

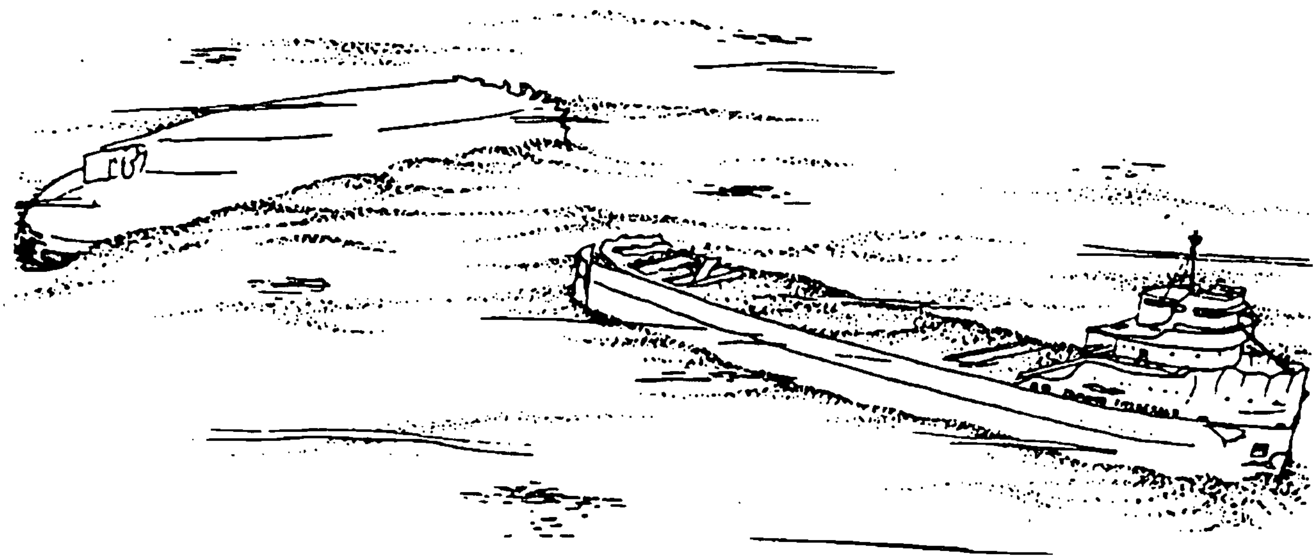


Figure 9. The *Edmund Fitzgerald* as it appears on the bottom of Lake Superior. (Artist's conception based on Coast Guard data)

	Expected Responses
Team 2 Shows Maps 1 and 2, then transparencies they constructed for Maps 3-4, pointing out the general direction in which the storm was moving.	The storm was moving toward the northeast, as shown by movement of the LOW.
Leader When a low pressure center is on the map, it generally means unsettled weather. How do winds blow around a low pressure center?	Counter-clockwise flow toward the center, with stronger winds near the center.
Team 2 Gives answer to question 2.	
Leader On your transparencies, show us what types of areas have higher winds and waves. **Team 2** Gives answers to questions 3-5 and shows transparency sections to illustrate:	Wind and waves: Higher in coastal areas than mid-lake (Map 1) Mid-lake and islands about the same (Map 1) Canadian and U.S. sides about the same (Map 3)
Leader Team 2, do you think the *Fitzgerald* chose the safest route, or could you plot a safer one?	Answers will vary.

Team 2
Shows transparency with a "better" *Fitzgerald* route and explains the reasons for choosing the route. General discussion of Team 2's choices. There are no correct answers.

Leader
Team 3 has information about the bottom of Lake Superior and how the uncharted features could cause ships to wreck. Team 3, how do we know what's on the floor of a lake or ocean?

Team 3
Responds according to the introduction of its activity. Shows map done as practice.

Leader
Let's look at the area where the *Fitzgerald* sank. Team 3, what do the bathymetric contours tell us about the lake bottom in this area?

Team 3
Shows tracing of contours and points out shallow areas.

Leader
Tells about the "Three Sisters" waves described in the article attached (a fourth explanation of what might have happened).

CONCLUSION

At this point, the Base Group leader should pull together the information from all teams and emphasize the following:

- A combination of natural forces and possible human error could account for the sinking of the *Fitzgerald.*
- Many disappearances within the lakes triangle are in heavy traffic areas (narrow stretches of water, busy airports, etc.). Compare this with the accident rate on the busiest street in your community and the accident rate on a little-travelled route.
- There is probably no single explanation for all the accidents in the Great Lakes triangle, but it is likely that logical reasons for the losses could be found.
- This investigation has been a piece of scientific detective work – the putting together of pieces to reach a logical conclusion.

The Sunday Journal

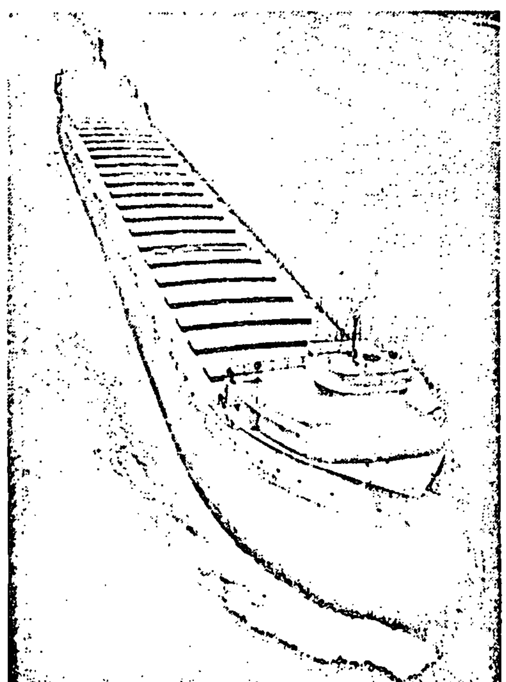
First Section

Marquette, Michigan

25 cents

Did 'three sisters' pull it down?

Fitzgerald: Another theory



THE EDMUND FITZGERALD

EDITOR'S NOTE: Lyle McDonald, who now lives in Laurium, is a former commercial fisherman on eastern Lake Superior at Grand Marais. His family has been in the commercial fishing business for years. Some of the shoals and reefs in the area of the Fitzgerald sinking were discovered by and named for his ancestors. An uncle was keeper at the Caribou Island light for many years.

By LYLE MCDONALD
Special to the Sunday Journal

Seafaring men and their families throughout the world waited almost two years to learn the findings of the U.S. Coast Guard board of inquiry regarding the sinking of the freighter Edmund Fitzgerald.

The statement released recently by the board that the ship probably sank because of seepage through the hatch covers was somewhat of a disappointment. One hesitates to dispute the judgment of such a group of knowledgeable people who spent so much time and money to come up with their findings, but they certainly did not release any information as to how the disaster could have been avoided or how future similar situations could be avoided.

It seems to be the consensus among sea-going men that seepage could have been somewhat of a contributing factor. However, the lip-seal design of hatch covers on freighters is such that very little seepage could occur.

The Fitzgerald was a relatively new ship. We should give the captain, crew, owners and designers some credit. No captain and crew would leave a Lake Superior port at that time of year without first insuring the hatch covers were properly secured and battened.

My license to make the above statements and offer my explanation of this traumatic disaster has been earned through many years as a captain of commercial fishing tugs on Lake Superior, primarily out of Grand Marais—very close to the present location of the Fitzgerald.

Throughout the years, the greatest battles with Lake Superior have been waged by commercial fishermen. Personally, I have waged many such battles. Knowledge of the sea's actions, the size and capabilities of the ship, courage, judgment and the Grace of God have enabled me to win all of those battles and respectfully submit my version of the tragedy.

The Fitzgerald went to the bottom of Lake Superior by means of submarining, due to excessive water weight on the decks of her forward section, immediately aft of the pilot house.

THREE SISTERS

The absolute key to this tragedy lies in the Three Sisters—or three big seas! I am amazed that this phenomenon has not been considered. Commercial fishermen, and all men who have spent considerable time on Lake Superior during storms, know that at irregular intervals, three larger waves appear. Fishermen, throughout the years, have timed and utilized these three big waves to successfully gain entrance to dangerous harbors when the wind is blowing off the lake.

To further understand this phenomenon, stand on the beach when the wind is blowing off the lake, and periodically, three waves will come higher on the sand than the others. This phenomenon of the three big waves is much more pronounced during a big storm, in the middle of Lake Superior, and in the fall and winter months.

Although the three big seas was the key to the disaster, many other elements have to have been precise to conquer this gigantic, magnificent ship. Some of the factors that have to be considered are: Wind direction and velocity, speed of seas, distance between seas, direction of ship, speed of ship, weight of cargo, buoyancy-displacement ratios, depth of water, contour of ship bow and inertia.

We know the wind was blowing approximately 70 mph out of the northwest. The speed of the ship would have been approximately 16 mph. A look at the chart will show that the course to Sault Ste. Marie, at the point where the ship was found, would have been approximately southeast.

73

BEST COPY AVAILABLE

74

Fitzgerald: Another theory

(Continued from page 1)

Importantly, note also that it had become necessary to change course after clearing Crisp Point, shortly before the tragedy. Consequently, the ship was traveling almost directly before the seas.

On Lake Superior, in November in deep water when the wind is blowing at 70 mph, the seas travel at approximately 25 mph and are spaced between 100 and 150 feet apart. We know that her decks had been awash previously. When the captain changed course, it enabled the three big seas to sweep up the full length of her decks, and the back-wash from the first sea was met by the second, and the backwash from both were met by the third. Since the seas were traveling almost twice as fast as the ship, this permitted a tremendous fluid weight to remain on the forward section.

The actual time lapse from the time the first big sea hit aft of the pilot house until the third one hit would have been approximately 10 seconds. Because of her great width, these three seas would have remained on her forward deck for approximately 20 seconds.

The ship was 729 feet long and had an 80-foot beam. The area of the forward 325 feet of the ship would be 26,000 square feet. If those three big seas massed on this section of the ship for 20 seconds, the adding water weight would be 10 million pounds at an average depth of six feet. During this time the ship would have moved forward approximately 50 feet.

HEAVILY LADEN

She was laden with 52 million pounds of iron ore pellets. This additional 10 million pounds of water for 20 seconds, and a travel distance of only 50 feet, caused the entire plane of the ship to depress from horizontal to from 5 to 15 degrees below horizontal. At this point, her decks were under or almost under the surface. Because her bow and sides were perpendicular to the water, her buoyancy-displacement factor became decreased to a point where inertia prevailed and she continued her course to the bottom.

With the terrific weight, speed and the forward force of the propellor, it is doubtful if the angle of descent would have increased much during the relatively short distance of 350 feet to the bottom. This angle would increase somewhat as the ship descended, because water pressure increases with depth. When the bow plowed into the clay bottom of the lake, the stern section would have been close enough to surface to permit time and space for the stern section to capsize after she snapped.

Were we to believe the findings of the Coast Guard board of inquiry, whereby she sunk because of seepage through the hatches, she would likely have seeped water through hatches both forward and aft, and would have settled to the bottom on a horizontal plane, and the aft section would not have had space or time to be upside down.

WHY IT HAPPENED

We have dealt with how this tragedy occurred, now let us consider why it happened, how it could have been prevented and what lessons it can teach people who put out to sea in boats.

The Edmund Fitzgerald lies on the botom of Lake Superior today, with it's full crew of 29 men trapped inside her, because the captain did not realize he was in danger. Prior to this tragedy, the Great Lakes ships had become so large, so well constructed, so fast and so completely equipped that the captains thought they were unsinkable.

Had the captain realized the storm could sink his ship, he could have gained shelter on the south side of Michipocoten Island or, later in the day, sought shelter under the north shore, on the Canadian side of the lake.

Had he known the ship could sink, he could have reduced his speed or utilized the old sailboat tactic of "tacking" before the wind. Had his speed been half, that massive body of water would have dissipated twice as fast.

Those of us who operate ships, regardless of size, should have learned many things as the result of this tragedy in which Lake Superior was able to swallow a ship of the magnitude of the Fitzgerald. Books have been written, and probably should be revised because of the tremendous number of relatively small pleasure craft, on water safety.

The cardinal lesson to be learned from the Fitzgerald tragedy is that one should never underestimate the ferocity and power of Lake Superior. Conversly, never overestimate the capabilities of your craft. A good operator does not get caught in a storm greater than the capabilities of his boat. However, if it does happen, common sense should prevail.

Any ship will survive a storm much better if the speed is reduced. If the situation gets to a point where shelter cannot be reached, any ship will weather a storm much better if she is held into the wind, with just enough propulsion to maintain steerageway.

8 The Journal, Lorain, Ohio Thursday, September 29, 1977

Fitzgerald Hit Reef, Latest Report Says

DULUTH, Minn. (AP) — The Lake Carriers' Association says the ore carrier Edmund J. Fitzgerald sank after striking a shoal, or underwater reef, nearly two years ago in storm-tossed eastern Lake Superior.

The association rejected the theory of the U.S. Coast Guard, which found that the "most probable cause" of the disaster was loss of buoyancy and stability resulting from massive flooding of the cargo hold through ineffective hatch closures.

The association, composed of 15 domestic bulk shipping companies operating 135 vessels on the Great Lakes, filed its position paper Wednesday with the National Transportation Safety Board, asking that it be considered in the board's deliberations in the case.

The paper was written by Paul E. Trimble, a retired Coast Guard admiral who is association president.

Trimble cited 40 years' experience with the type of hatch covers and closure clamps in use and said if they were ineffective there would have been many watery cargoes to unload.

This would have been a "costly problem that vessel and cargo owners would not tolerate," he said.

Testimony about improper hatch closure procedures on other vessels in other than heavy weather conditions "should under no circumstances be assumed to have been the case on the Fitzgerald in the weather she was experiencing," Trimble said.

He cited testimony before the board about the Fitzgerald's course shortly before it sank Nov. 10, 1975. Some of it was presented by the captain and a mate of the ore carrier Arthur Anderson, which was providing navigational assistance to the Fitzgerald after radar failure.

While no plot of the Fitzgerald was maintained, the captain of the Anderson said the Fitzgerald was close to SixFathom Shoal north of Caribou Island.

Trimble's other arguments in opposition to the Coast Guard's findings included:

—MINUTES after passing Six Fathom Shoal, the Fitzgerald reported a list and said two tank vents had been carried away and that two ballast pumps were operating.

—THE CAPACITY of the ballast pumps—14,000 gallons per minute—was adequate to handle the volume of water that could enter through the eight-inch diameter vents.

—THERE SHOULD have been no list, particularly in 10 to 15 minutes, from water from this source.

—THE FITZGERALD'S report of listing in such a brief period "can only be readily explained by holing of the vessel's ballast tanks caused by striking Six Fathom Shoal."

—THERE WAS NO REPORT of hatch damage or hatches opening.

—IT IS QUESTIONABLE that water in the cargo hold would have resulted in a list since it would not have been restricted to one side of the vessel.

—THE FITZGERALD'S MASTER reported the pumps were operating and "we are holding our own" minutes before the ship disappeared from view on the Anderson's radar.

—THE QUANTITY of water needed to sink the Fitzgerald "could not have seeped through the hatch covers."

Trimble said the Fitzgerald "labored in heavy, quartering seas for over three hours" after the initial damage caused by shoaling.

When buoyancy became marginal, a large wave or series of waves could have raised the stern, starting the bow's dive under water, Trimble theorized.

He said hatch covers could have been blown off by compressed air in the cargo compartments as water entered from the sides or bottom, or they could have sprung from the weight of taconite pellets cargo as the vessel dove in 530 feet of water.

Underwater photographs of the wreckage, he said, do not support a conclusion that the hatch clamps were not properly closed, he said.

What happened aboard the *Edmund Fitzgerald*?

On November 10, 1975, the Great Lakes ore carrier *Edmund Fitgerald* sank in the area of the Great Lakes Triangle. Though its wreckage was found, no members of the ship's crew were ever recovered. The sinking thus became not only a new piece of the triangle's mystery; it became a human story as well.

Strong emotions are often expressed more effectively through an artistic creation than through spoken words. A violent painting or a joyful dance can communicate feelings that anyone can understand. The deep sorrow felt in the lakes country when the *Edmund Fitgerald* sank was expressed in a haunting ballad by Canadian singer, Gordon Lightfoot.

Source

OEAGLS EP-17C, *The Great Lakes Triangle*, by Rosanne W. Fortner and Daniel W. Jax.

Earth Systems Understanding

This activity focuses on the use of the arts, ESU 1.

Materials

- Recording of Gordon Lightfoot's "The Wreck of the *Edmund Fitzgerald*."
- Words to that song.
- Pencil or Pen.

THE WRECK OF THE *EDMUND FITZGERALD*

The legend lives on from the Chippewa on down
of the big lake they call "Gitche Gumee."
The lake, it is said, never gives up her dead
when the skies of November turn gloomy.
With a load of iron ore twenty-six thousand tons more
than the *Edmund Fitzgerald* weighed empty,
That good ship and true was a bone to be chewed
when the "Gales of November" cam early.

The ship was the pride of the American side
coming back from some mill in Wisconsin.
As the big freighters go it was bigger than most
with a crew and good captain well seasoned,
Concluding some terms with a couple of steel firms
when they left fully loaded for Cleveland.
And later that night when the ship's bell rang
could it be the north wind they'd been feelin'?

The wind in the wires made a tattle-tale sound
and a wave broke over the railing.
And ev'ry man knew as the captain did too
'twas the witch of November come stealin'.
The dawn came late and the breakfast had to wait
when the Gales of November came slashin'.
When afternoon came it was freezin' rain
in the face of a hurricane west wind.

When suppertime came the old cook came on deck
sayin', "Fellas, it's too rough t' feed ya."
At 7:00 p.m. a main hatchway caved in;
he said, "Fellas, it's been good t' know ya."
The captain wired in he had water comin' in
and the good ship and crew was in peril.
And later that night when 'is lights went outta sight
came the wreck of the *Edmund Fitzgerald.*

Does anyone know where the love of God goes
when the words turn the minutes to hours?
The searchers all say they'd have made Whitefish Bay
if they'd put fifteen more miles behind 'er.
They might have split up or they might have capsized;
they may have broke deep and took water.
And all that remains is the faces and the names
of the wives and the sons and the daughters.

Lake Huron rolls, Superior sings
in the rooms of her ice water mansion.
Old Michigan steams like a young man's dreams;
the islands and bays are for sportsmen.
And farther below Lake Ontario
takes in what Lake Erie can send her,
And the iron boats go as the mariners all know
with the Gales of November remembered.

In a musty old hall in Detroit they prayed,
in the "Maritime Sailors' Cathedral."
The church bell chimed 'til it rang twenty-nine times
for each man on the *Edmund Fitzgerald.*
The legend lives on from the Chippewa on down
of the big lake they call "Gitche Gumee."
"Superior," they said, "never gives up her dead
when the Gales of November come early!"

Objectives

In completing this activity you should be able to:

- Give examples of the amount of information that can be conveyed in memorable form in a song.
- Describe how music can convey emotions.
- Use the ideas from a song in your personal writing.

Procedure

1. Listen to the recording. How does it make you feel? For each of the following things about the song, tell how it helps to produce this general feeling:

   A. The singer's voice.

   B. The tempo (how fast the song is).

   C. The instrument being played.

   D. Sounds in the background.

   E. The words (list words or phrases that help create the feeling.

2. Imagine that you are aboard the *Fitzgerald* on the night of the storm. The darkness and the cold rain are uncomfortable, but until now no one had doubted that you will reach your destination. The song reports that "at 7:00 P.M. a main hatchway caved in." Write a one-page description of what you might have witnessed aboard the ship as it sank. This can be done as if you are recording events in a diary or writing a last letter to a friend. Since you have probably decided for yourself what must have happened that night, this is a way of providing the world with an "eyewitness" account of the events.

Extension

The last messages from ships and planes that have disappeared are examined in Berlitz's book, *Without a Trace*, a follow-up to *The Bermuda Triangle*. The book also includes the testimony of witnesses and survivors,enlarging the mystery of the Triangle. As you read these accounts, search for ways to explain the happenings naturally. Both Berlitz's and Gourley's books imply that forces from outer space are responsible for triangle disappearances. Though this idea is an interesting one, most scientists would tell us that science fact is stranger than science fiction. It is very likely that some natural factors such as those you investigated in this activity have been responsible for disappearances in both the Great Lakes and the Bermuda Triangles.

Answers

1. Student feelings will differ but will probably be expressed as worried feelings followed by sadness.

A. The singer's voice is low and clear. "He sounds sad," many students say.

B. The tempo is very slow and rhythmic. It seems to roll and lumber along.

C. The instrument is a steel guitar. The rhythmic rise and fall is created with a "bottle slide."

D. Background sounds are like storm waves rising and breaking against the ship. After the ship sinks, storm waves are no longer heard.

E. Lyrics that create a mood include: *never gives up her dead, gloomy, a bone to be chewed, the witch of November, slashin', peril, the words turn the minutes to hours, etc.*

There are more things in heaven and earth...than are dreamt of in our philosophy.

– Shakespeare

A FINAL NOTE

As this activity was being prepared, another incident was added to the Great Lakes Triangle mystery. This incident did not result in the loss of the plane or any lives, but it is the type of accident that makes people believe that unnatural things are happening in the Triangle. Try to figure out what natural forces might have caused this near-disaster.

Columbus Dispatch FRI, APRIL 6, 1979

Survival Of Supersonic Dive Called Miracle

DETROIT (AP) — The 80 passengers aboard the TWA flight from New York to Minneapolis had just eaten a midair snack when they felt the craft begin to vibrate.

Suddenly, the plane swerved to the right, completed a 360-degree barrel roll and nose-dived from 39,000 to 12,000 feet — five miles — in a matter of seconds at a speed apparently exceeding that of sound.

"YOU COULD FEEL your face pressed back and the blood rush to your head," said Chell Roberts, 22, a University of Utah student who was aboard. "Everyone was screaming. I thought it was over."

"We were just through eating when it happened ... people started to scream and a flight attendant started to cry," he said. "It's really a funny feeling to see what everybody does before they think they are going to die."

But nobody died Wednesday night. Only three people aboard suffered minor injuries.

FEDERAL AVIATION Administration (FAA) inspectors said it was "miraculous" and "unprecedented" that the Boeing 727 jetliner survived such midair trauma before being brought under control in a desperation maneuver. Langhorne Bond, head of the FAA, commended the pilot, identified only as H. Gibson of Chicago.

"I can't think of any other incident where a (commercial, passenger) plane has done a complete 360-degree rollover and survived," Bond said Thursday. "The miracle is that it held together under such extraordinary speed and circumstances."

Preliminary evidence, Bond said, indicated that the flight was "very routine in clear weather" when the plane "began to vibrate, went out of cruise control, rolled to the right, did a complete turnover and dived to the ground."

"WE DON'T KNOW what caused it at this time," Bond said.

At that point, the pilot tried to slow the descent by deploying devices on the plane designed to increase drag. But the wing flaps, spoilers and leading-edge slats proved ineffective at the speed the plane was traveling and were torn off.

The pilot then lowered the landing gear.

"It is clear that that is the event that allowed the crew to regain control of the plane," Bond said.

"THERE IS NOTHING in the manual to tell you what to do," he said, commending the pilot.

Bond and other FAA officials flew in from Washington to survey the damaged craft at Detroit Metropolitan Airport. The plane, with a seven-member crew, made an emergency landing at 10:30 p.m. Wednesday.

Propped up by jacks, the plane sat on an airport side runway as mechanics, FAA officials and reporters examined the damage. Flaps on the right wing were ripped off during the descent. Pieces of metal hung from that wing and from the fuselage around the landing gear doors on both sides. Inside the airliner, newspapers and magazines were strewn on the floor. A large sack of used airsickness bags stood in the aisle.

TWO TAPES, ONE recording cockpit conversations and one recording radio conversations with the ground, were sent for study to the National Transportation Safety Board in Washington.

Chuck Foster, associate administrator of the FAA for aviation standards, said the plane was flying about 500 mph before the trouble hit, but in the dive apparently exceeded 650 mph — above the speed of sound at that altitude and temperature.

"I've been told that the airspeed indicator was pegged all the way over to the edge," Foster said. "If that proves to be the case, it will be the first time in FAA history that an airplane (not designed for it) had exceeded those speeds and survived."

How were early canal routes determined?

The population of Ohio reached over 600,000 in the early 1800s, yet the state remained one of the poorest in the Union. Ohio was primarily an agricultural state. Its farmers lacked good ways of getting products to the East where the major population centers of the young nation were located. In 1825, a barrel of flour sold in Ohio brought $1.95. In New York City the same barrel of flour was worth $8.00. For Ohio's economy to prosper, a way had to be found to deliver the agricultural goods to cities such as New York.

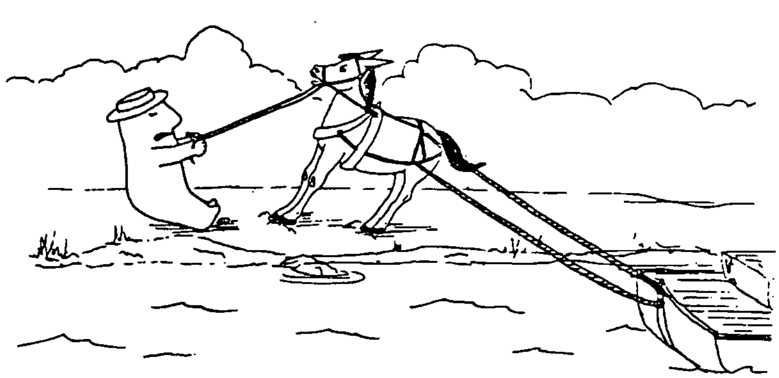
The completion of the Erie Canal through New York State in 1824 provided the towns along Lake Erie such as Buffalo, New York, and Cleveland, Ohio, with a way to move their products to the East. But how could produce from the interior part of Ohio be transported north to the lake? Ideas for a canal to link Cleveland with Columbus, the state capital, and with Portsmouth on the Ohio River, began to materialize. People in other areas of the state wanted canals also. If a canal were available, it would cost the farmer $1.80 to ship that barrel of flour to New York. This would provide an increase in profit of over $4. No wonder there was such interest in digging canals in Ohio!

How were the routes for the canals determined? What effect did they have upon the economy of the states and of the towns along their paths? The following pair of activities focuses on an Ohio example of this unique type of transportation to and from the Great Lakes.

Objectives

When you have finished this investigation you should be able to:

- Point out reasons for the location of major canals in a Great Lakes state.
- Locate information on the Internet about the canals in other Great Lakes states.



Source

OEAGLS EP-15, *Ohio Canals*, Activity A, by Victor J. Mayer and Frank Pigman

Earth Systems Understandings

This activity uses ESU 3, map interpretation as a science process, and ESU 4 which illustrates how topography affects water flow, and ESU 7, careers.

Materials

Per team:
- One laminated copy of the map titled "Principal Streams in Ohio."
- Two different colors of washable marker pens.

For the class (optional):
- Filmstrip set, *Ohio's Canal Era.*
  CM 1825
  Cinemark Productions
  1761 Karg Drive
  Akron, Ohio 44313

Procedure

Two reasons were most important in locating the canals in Ohio. First, canals had to serve the largest population and industrial centers. Second, they had to take advantage of natural waterways such as streams. Following streams helped to reduce the amount of digging, since streams go around hills and usually have gentle slopes. They also guaranteed a supply of water for the canal. The first canal completed was the Ohio-Erie. It served the population centers of Cleveland, Columbus, and Portsmouth.

1. Using your marker pen, trace on the laminated map what you think would be the best route for the Ohio-Erie Canal. Write down your reasons for choosing this route.

2. The Miami-Erie Canal was to serve the cities of Toledo, Dayton, and Cincinnati. Trace a route for the Miami-Erie Canal. Write down your reasons for choosing that route.

3. Your teacher will show a map of the actual canal routes. Using a different color of pen, trace out the actual routes followed by the two canals. Also, trace the routes of other canals constructed in Ohio.

4. Where do your routes differ from those actually chosen by the canal builders? Examine your map in these regions. Why do you think the canal builders chose routes other than those you chose?

A drainage divide is high land that separates the areas drained by two different streams.

5. Locate Lake St. Marys and Buckeye Lake. Both are reservoirs built at the time of the canals. Note their location and the location of the drainage divides. Why do you think these two lakes were built?

The drainage divide will be located between the tips of the smallest tributaries of the two major streams or rivers.

Answers

1-2. Students should logically explain their choice of canal routes. A canal route should guarantee an adequate supply of water and the most gentle gradient available. Generally, this will mean that it would need to be located close to a major stream and its major tributaries. The canal route may have to depart from the ideal route to bring it closer to the major population centers it needs to serve.

3. Make a transparency of the full-page map for use on an overhead projector. Then have students draw in the correct canal routes on their maps as they examine them on the transparency.

4. The student's answer should identify major departures of their routes from the actual routes. Reasons for differences could include location of other population centers than those considered by the students, water supply, location of drainage divides, stream size, nature of the topography, and the underlying geology of the region.

   Some reasons may not be apparent from the map. For example, who was in power in the state legislature when the laws establishing the canals were passed? Where did they live? Often an influential political figure will use power to get public works in his/her district or home town. There are other reasons as well. For example, the western canal did not start in Sandusky because it would have had to run through Indian lands. It would have been difficult to get the rights to the route and to protect the canal once it was operating.

5. Lake St. Marys and Buckeye Lake were built to supply water to locks that lifted canal boats over drainage divides.

6. There are other lakes along the route of the canals that served the same purpose. Name some of them.

7. At what types of places do you think the canal builders had the greatest difficulty in building the canals? Why?

Just as Ohio markets stood to benefit by gaining access to lake transportation routes, so did those in other states. The class will be divided into teams to check the following Internet sites for information similar to what you have just learned about Ohio canals. Your new information sources may provide valuable supplements to the activity titled "How did the canals affect Ohio?," as well as answering that question for other states.

The Erie Canal
http://www.history.rochester.edu/canal/

Illinois & Michigan Canal
http://members.aol.com/canal/two/private/in_main.htm

Canals and Inland Waterways
http://www.coe.wvu.edu/~wwwmae/asa/am-riv.htm

Digital Tradition Folk Song
http://pubweb.parc.xerox.com/digitrad/song=ERICANL1

Ohio's Historic Canals, The Canal Society of Ohio
http://www.infinet.com/~lstevens/canal/

REVIEW QUESTION

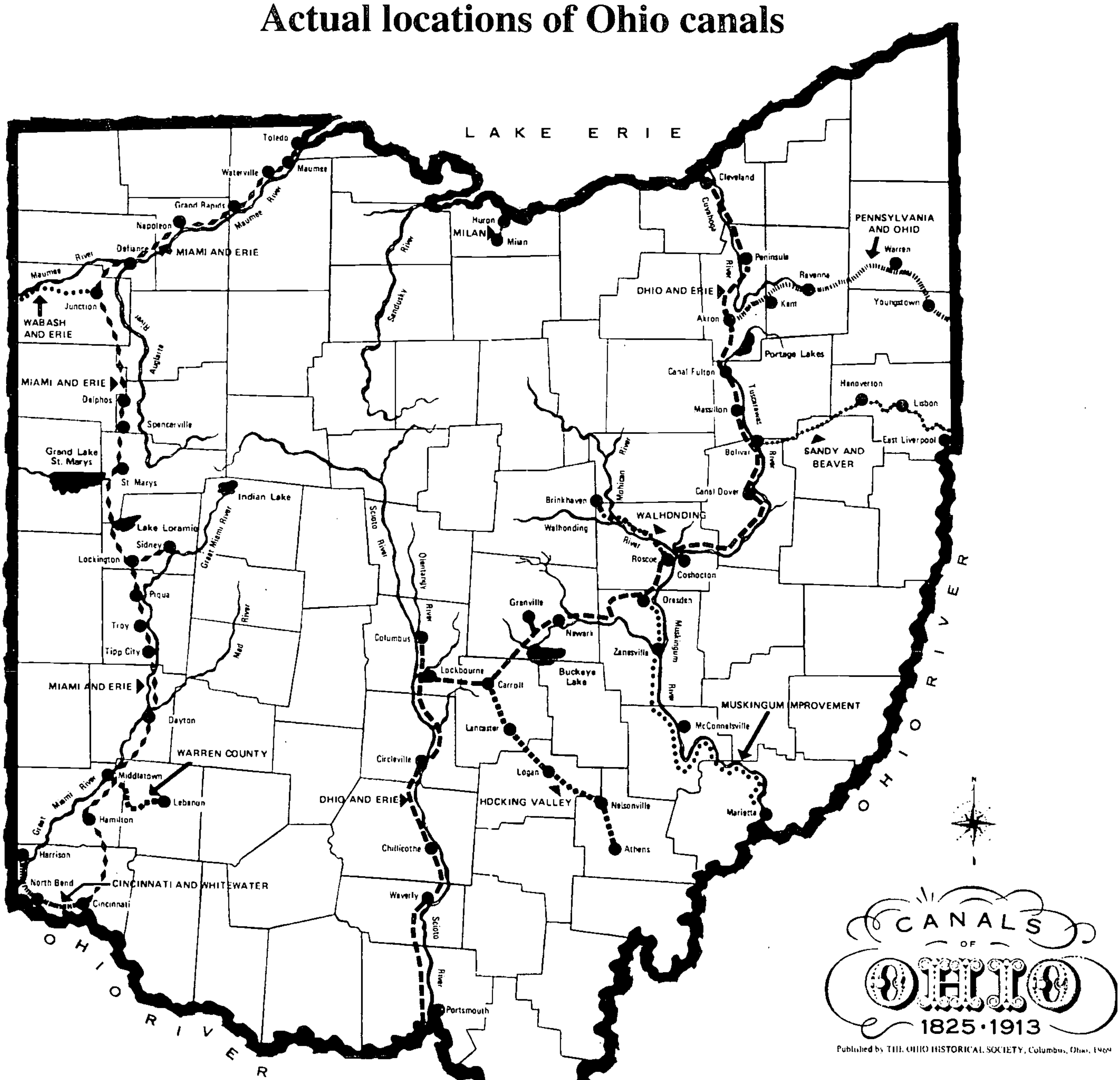
What were the major factors to be considered for locating canals?

The Ohio Coat of Arms

6. Lake Loramie, Lake Logan, Guilford Lake, and Lake Rockwell are all possible water supply reservoirs. However, most of the lakes designated on the map as water reservoirs have been developed since the canal era. Their principal roles are flood prevention and water supply for municipalities.

7. Areas of high relief at the drainage divides were particularly difficult. They required many locks. For example, there were 11 locks built through Akron to lift the boats from the Cuyahoga drainage basin into the Muskingum River Basin.

Actual locations of Ohio canals



How did the canals affect Ohio?

Using data on population growth and economic activity of selected cities, we can study the possible effects of the canals on these same cities. Use the correct canal routes drawn for the activity, "How were the early canal routes determined?"

OBJECTIVES

When you have finished this activity you should be able to:

- Discuss the flow of products along the canals and into the nation's markets.
- Analyze the impact of the canals on a state's economy and population.

PROCEDURE

Because the canals made it easier for people to travel and to ship materials, they had an effect upon many of the cities in Ohio. Figure 1 lists percentage of population increases during 10-year time spans for several of Ohio's cities. For example, the population of Chillicothe increased by 79 percent during the decade 1840-1850. At the bottom of Figure 1 are several events that happened during particular decades.

Source

OEAGLS EP-15, *Ohio Canals*, Activity B, by Victor J. Mayer and Frank Pigman.

Earth Systems Understandings

ESU 2, 3, 4, social and economic data demonstrate the effect of technology on human culture and economy. ESU 5 the data indicate change over time, and ESU 7 careers are implied.

Materials

- Canal map from page 78.
- Four additional markers.
- Map of the United States.

Note: Of the cities in Figure 1, Mansfield is the only city that has never had any water transportation route available.

DECADES	1820-29	1830-39	1840-49	1850-59	1860-69	1870-79
Chillicothe	17	40	79	7	17	23
Cleveland	44	82	64	61	53	42
Columbus	—	60	66	4	41	39
Portsmouth	102	88	101	56	69	7
Mansfield	—	37	63	22	43	19
Marietta	—	33	75	27	17	42
Cincinnati	61	87	149	48	34	18
EVENTS	Erie Canal in New York and southern part of the Miami Canal complete	Ohio-Erie Canal complete in 1832	North part of Miami-Erie canal complete	Railroads widespread in Ohio by 1860		

Figure 1. Population growth of certain Ohio cities.

Answers

1. Chillicothe grew very rapidly between 1830 and 1850, and then its growth rate dropped to a very low point between 1850 and 1860. Chillicothe's growth began to increase because of the opening of the Ohio-Erie Canal in 1832. The development of railroads in Ohio by 1860 and the consequent decrease of trading along the canals may be the cause of the decreased growth rate in the decade 1850-1860.
2. The growth rate of Cleveland accelerated after the opening of the Ohio-Erie Canal in 1832. This high growth rate was sustained after the development of the railroads since Cleveland also became a rail center.
3. Columbus's period of most rapid growth occurred in 1840-1850, after the opening and use of the Ohio-Erie Canal. Being linked to both the Ohio River and Lake Erie by the canal had a large influence on the growth of Columbus during this time period.
4. Mansfield is located some distance from a canal. Therefore, although its population showed rapid growth in 1840-1850, the growth could have been only indirectly affected by the canals.
   An extension from the Ohio-Erie Canal was completed along the Muskingum River to Marietta in 1841. It was probably responsible for the spurt in population in Marietta during that decade. Its population growth then leveled off, especially after the railroads bypassed Marietta.
5. Cincinnati grew tremendously from 1820-1850 when the northern part of the Miami-Erie Canal opened and Great Lakes traffic could get to Cincinnati. After 1850, there was a decline in growth rate possibly due to the expansion of the railroads.

Find each of the cities in Figure 1 on your map of Ohio. Were any located on canals? If so, which ones? Are any located on Lake Erie or the Ohio River?

Examine the population changes for each of the cities (Figure 1). Then answer the questions.

1. What reasons can you think of that could explain the way Chillicothe grew between 1820 and 1860?
2. Did the opening of the Ohio Erie-Canal seem to have any effect upon the population growth of Cleveland. Explain.
3. During what period of time did Columbus grow most rapidly? What might have caused this growth?
4. Could the canals have had any effect upon the growth of either Mansfield or Marietta? Discuss.
5. Describe the growth of Cincinnati. Does it seem to be related to the canals? Discuss. Which of these might have affected any of the cities above?

Because canals eased the movement of products from place to place, certain cities were able to specialize in types of products. This increased the dependence of cities upon each other. Raw materials would be produced at one place along the canal. They would be taken to another city to be used in manufacturing. The canals also allowed products to be shipped to other states and even to foreign countries.

Figure 2 lists four cities and the products they specialized in during the 1825-1850 period.

Cincinnati	Cleveland	Troy	New Philadelphia
pork packing	beer	lumber	wood
container making	iron machinery	hogs	grain
clothing	flour	grain	meat & dairy products
liquor	ship building		

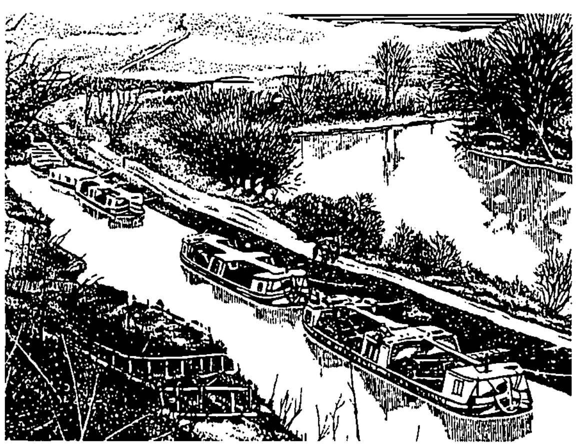
Figure 2. Products of Ohio cities during 1825-1950.

6. There are many things other than the opening of transportation routes that could affect the growth of cities. Discuss any you can think of.

7. Locate Cincinnati and Troy on the Miami-Erie Canal. Draw arrows along the canal from Cincinnati in the direction that its products might move. Use a different colored marker and do the same for Troy.

8. In what ways might the lumber shipped from Troy be used in Cincinnati?

9. Where else do you think Cincinnati's products might have been sent? Use a map of the U.S. to answer this question. Describe the route that might be taken by these products.



After Ohio's products reached an ocean port they could be shipped anywhere in the world. Ohio's canals, therefore, opened Ohio to the world markets. They also allowed the importation of foreign products.

10. Now locate Cleveland and New Philadelphia on the Ohio-Erie Canal. Draw arrows indicating the movement of materials between the two cities.

11. What were some of the uses made of grain that was shipped from New Philadelphia to Cleveland?

12. Where else do you think Cleveland's products might have been shipped? Again use the map of the U.S. Describe the route that might be taken by these products.

13. Of the four cities in Figure 2, which two manufactured materials? Which two cities produced materials used in manufacturing?

6. This question should cause students to think more deeply about the causes of population change. Some may be local, such as a disaster. Others may be related to natural features - the development of a new resource, such as coal mining or oil wells. Accept any that seem to be reasonable. Encourage creativity.

7. Cincinnati would send products up the canal toward Troy, as well as downstream on the Ohio. Troy could send products to Cincinnati and to Toledo.

8. It was certainly used in the containers made in Cincinnati, especially barrels. Uses included building, other purposes.

9. Cincinnati's materials could move up the canal to the Great Lakes and out to the Atlantic. Even before the canal opened, they could move on the Ohio River, downstream to the Mississippi and New Orleans. New Orleans was the major market for Ohio goods in the early 1800s, but prices paid there were low. Since the Ohio merchants could not return goods upstream, they were forced to accept these low prices. The canal was a real boon to Cincinnati, the pork capital of the World, since it opened up the markets on the Atlantic seaboard.

10. Cleveland could send products down the canal as well as both ways on Lake Erie. New Philadelphia probably sent most of its products toward Cleveland.

11. Grain was used to make beer and flour.

12. With the opening of the Erie Canal, Cleveland's products could go east through New York State to the Atlantic.

13. The canal permitted the shipment of hogs from Troy to Cincinnati for slaughter and packing. Grain could be shipped to Cincinnati for use in making liquor. New Philadelphia could supply Cleveland with food and with wood for use in manufacturing.. The processed materials could, of course, flow back to the points of origin. In this way, cities began to specialize in the types of products they provided within the economy of Ohio. This gave birth to the manufacturing centers of Cincinnati, Cleveland, Toledo, Akron, and Dayton.

Review Questions

1. How did the canals affect the population growth of certain cities?

2. Explain how the canals led to specialization of the products supplied by different areas or towns in Ohio.

3. How did the canals tie midwestern towns into world markets?

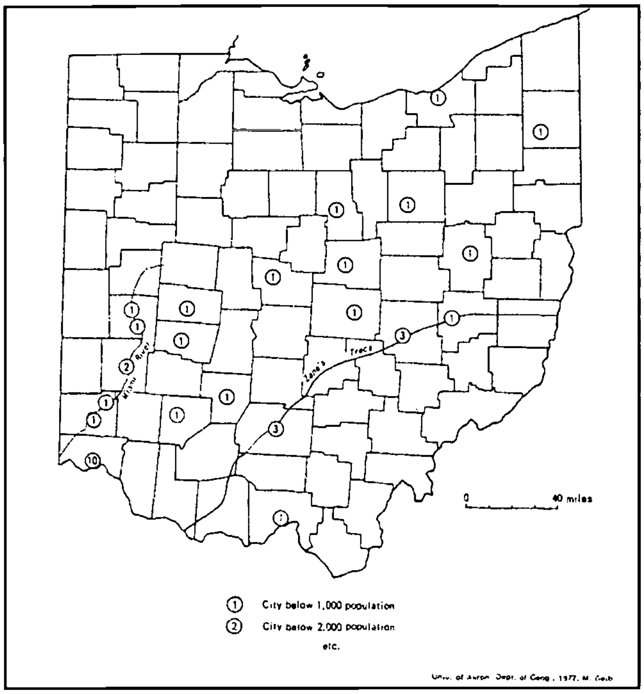
Background Information

The growth rate of cities in Ohio has from the beginning been linked with the accessibility of transportation. By 1820, Cincinnati was the largest city in Ohio. The next largest cities were situated along a roadway called Zane's Trace. In the ensuing decade, cities along the Scioto, Miami, and Mad Rivers began to grow as a result of the increased use of these rivers for transportation. State routes developed outward from these major cities. (See maps, page 83).

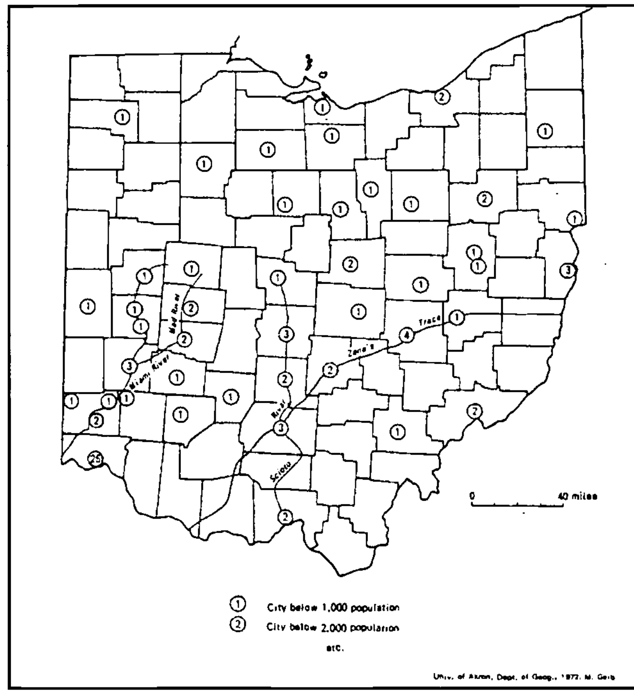
The building of the canals in Ohio in the 1830s and 1840s significantly altered the growth patterns of various Ohio cities. The later half to the 19th century, however, was dominated by railroads. Railroads were originally built to reach areas not reachable by the canals, but it became apparent that railroads could favorably compete with the canals. Toledo became a major railroad center and also became the third largest Ohio city by 1900. Along with railroad development was industrialization. The rise in importance of the truck and automobile led to the development of the modern highway systems and patterns of growth that we experience today.

As the boats moved slowly along the canals, the canallers spent much of their time singing. Some of these songs have been preserved. They tell much about canal life. The class can get song lyrics from state historical societies or from an Internet site for Digital Tradition Folk Songs:

http://pubweb.parc.xerox.com/digitrad/song=ERICANL1



To the Teacher: Population of selected cities, 1820.



Population of selected cities, 1830.
(Source: University of Akron, Dept. of Geography)

SUGGESTED APPROACH

This makes an ideal set for one expert group in the lake transportation jigsaw suggested on pages 4-5. Students can see why and how boats get into or out of the Great Lakes on their way to market destinations. Canals were also important in New York, and information on that state's growth would be valuable to include or substitute.

The activity could be followed by a showing of filmstrips from the set *Ohio's Canal Era*, Cinemark Productions, 1761 Karg Drive, Akron, OH 44313. Part 1 deals with the overall history of the Ohio canal system and how it affected the growth of Ohio's population and economy. Part 2 explores the route of the Ohio Erie Canal and its effect on cities along its route. Part 3 provides a similar treatment for the Miami-Erie Canal.

There are many sites around Ohio where portions of the old canals can be found and where the remnants of lock systems can be observed. There are restorations at Roscoe Village and Piqua. Other sites are identified on the Internet (http://www.infinet.com/~lstevens/canal/). Any of these locations can be an interesting field trip for students after they have studied this investigation.

REFERENCES

Noble, A.G. and Korsak, A.S. 1975. *Ohio – An American Heartland.* Ohio Geological Survey, Bulletin 65.

Wilcox, F.N. 1969. *The Ohio Canals.* William A. McGill, ed. The Kent state University Press.

Ohio Historical Society. *Canals of Ohio.* (Leaflet and map.) Columbus, Ohio.

The Big Ditch. Jim Baker's Historical Handbook Series available from the Ohio Historical Society.

The Ohio Historical Society. *Scenes and Songs of the Ohio-Erie Canal.* (Pictures and descriptions of the canals and several songs sung on the canal boats).

Framework for Earth Systems Education

UNDERSTANDING #1: Earth is unique, a planet of rare beauty and great value.
- The beauty and value of Earth are expressed by and for people of all cultures through literature and the arts.
- Human appreciation of Earth is enhanced by a better understanding of its subsystems.
- Humans manifest their appreciation of Earth through their responsible behavior and stewardship of its subsystems.

UNDERSTANDING #2: Human activities, collective and individual, conscious and inadvertent, affect Earth systems.
- Earth is vulnerable, and its resources are limited and susceptible to overuse or misuse.
- Continued population growth accelerates the depletion of natural resources and destruction of the environment, including other species.
- When considering the use of natural resources, humans first need to rethink their lifestyle, then reduce consumption, then reuse and recycle.
- Byproducts of industrialization pollute the air, land, and water, and the effects may be global as well as near the source.
- The better we understand Earth, the better we can manage our resources and reduce our impact on the environment worldwide.

UNDERSTANDING #3: The development of scientific thinking and technology increases our ability to understand and utilize Earth and space.
- Biologists, chemists, and physicists, as well as scientists from the Earth and space science disciplines, use a variety of methods in their study of Earth systems.
- Direct observation, simple tools, and modern technology are used to create, test, and modify models and theories that represent, explain, and predict changes in the Earth system.
- Historical, descriptive, and empirical studies are important methods of learning about Earth and space.
- Scientific study may lead to technological advances.
- Regardless of sophistication, technology cannot be expected to solve all of our problems.
- The use of technology may have benefits as well as unintended side effects.

UNDERSTANDING #4: The Earth system is composed of the interacting subsystems of water, rock, ice, air, and life.
- The subsystems are continually changing through natural processes and cycles.
- Forces, motions, and energy transformations drive the interactions within and between the subsystems.
- The Sun is the major external source of energy that drives most system and subsystem interactions at or near the Earth's surface.
- Each component of the Earth system has characteristic properties, structure, and composition, which may be changed by interactions of subsystems.
- Plate tectonics is a theory that explains how internal forces and energy cause continual changes within Earth and on its surface.
- Weathering, erosion, and deposition continuously reshape the surface of the Earth.
- The presence of life affects the characteristics of other systems.

UNDERSTANDING #5: Earth is more than 4 billion years old, and its subsystems are continually evolving.
- Earth's cycles and natural processes take place over time intervals ranging from fractions of seconds to billions of years.
- Materials making up Earth have been recycled many times.
- Fossils provide the evidence that life has evolved interactively with Earth through geologic time.
- Evolution is a theory that explains how life has changed through time.

UNDERSTANDING #6: Earth is a small subsystem of a Solar system within the vast and ancient universe.
- All material in the universe, including living organisms, appears to be composed of the same elements and to behave according to the same physical principles.
- All bodies in space, including Earth, are influenced by forces acting throughout the solar system and the universe.
- Nine planets, including Earth, revolve around the Sun in nearly circular orbits.
- Earth is a small planet, third from the Sun in the only system of planets definitely known to exist.
- The position and motions of Earth with respect to the Sun and Moon determine seasons, climates, and tidal changes.
- The rotation of Earth on its axis determines day and night.

UNDERSTANDING #7: There are many people with careers and interests that involve study of Earth's origin, processes, and evolution.
- Teachers, scientists, and technicians who study Earth are employed by businesses, industries, government agencies, public and private institutions, and as independent contractors.
- Careers in the sciences that study Earth may include sample and data collection in the field and analyses and experiments in the laboratory.
- Scientists from many cultures throughout the world cooperate and collaborate using oral, written, and electronic means of communication.
- Some scientists and technicians who study Earth use their specialized understanding to locate resources or predict changes in Earth systems.
- Many people pursue avocations related to planet Earth processes and materials.

The development of this framework started in 1988 with a conference of educators and scientists and culminated in the Program for Leadership in Earth Systems Education. It is intended for use in the development of integrated science curricula. The framework represents the efforts of some 200 teachers and scientists. Support was received from the National Science Foundation, The Ohio State University, and the University of Northern Colorado.

For further information on Earth Systems Education, contact the Earth Systems Education Program Office, 2021 Coffey Road, The Ohio State University, Columbus, OH 43210.

Sample Rubric

The rubric was developed by an Earth Systems teacher for use in evaluating individual student research projects.

Research Time Utilization	The student needed continual reminders to get back to work. Work may be inappropriate to the project.	The student was usually on task, but needed an occasional reminder to get back to work. All work is appropriate.	The student was always on task and did not need reminders to get back to work.
Participation in Project	The student does not add an equitable amount of work to the project and does not meet all requirements for the length of presentation.	The student adds an equitable amount of work to the project, but may not meet all requirements for the length of the presentation.	The student adds an equitable amount of work to the project and meets all requirements for the length of the project.
Accuracy of Information During Presentation	The student's information was lacking in content and was not factually correct in many places. Information may not be pertinent to the presentation.	The students' information is for the most part factually correct. Information may not be pertinent to the presentation.	The student's information is factually correct and pertinent to the presentation.
Clarity of Presentation	The student's work is not well planned. The student was confused by much of the information presented. The student was not clear in explaining topics.	The student's work is well planned. There seemed to be some confusion or misinterpretation of information.	The student's work is well planned and clearly explained. The student showed a clear command of the information presented.
Visual Aid Worksheet, or Simple Demonstration	The device used by the student was not used at a timely place in the presentation, had little bearing on the presentation, or was absent from the presentation.	The device used by the student was appropriate for the presentation. It may have been used in a more appropriate manner. The design of the device may not have maximized the learning.	The use of the device was timely and appropriate. The design of the device was constructed to maximize learning.

Source: Mayer, V.J. and R.W. Fortner, 1995. *Science Is a Study of Earth: A resource guide for science curriculum restructure.* Columbus, OH: Earth Systems Education Program, The Ohio State University.

Ohio Sea Grant Education Program

The Ohio Sea Grant Education Program has focused on the development of curriculum materials to enhance the quality of science education, the infusion of these materials into the classroom, and teacher training. Materials developed emphasize real-world issues including, most recently, the impact of global climate change on the region.

Earth Systems - Education Activities for Great Lakes Schools (ES-EAGLS)

ES-EAGLS are designed to take a concept or idea from the existing school curriculum and develop it in a Great Lakes context, using teaching approaches and materials appropriate for students in middle and high school. The activities are characterized by subject matter compatibility with existing curriculum topics, short activities lasting from one to three classes, minimal preparation time, minimal equipment needs, standard page size for easy duplication, suggested extension activities for further information or creative expression, teachability demonstrated by use in classrooms, and content accuracy assured by critical reviewers.

Each title costs $8.00

Land & Water Interactions in the Great Lakes EP-082
Great Lakes Climate & Water Movement................EP-083
Great Lakes Shipping EP-084
Life in the Great Lakes EP-085
Great Lakes Environmental Issues EP-086

The Great Lakes Solution Seeker

This compact disk will help educators teach their students about the Great Lakes by providing online or simulated Internet connections to comprehensive data sources, resources, graphics, and activities. The data and activities work best on Macintosh system 7.0 or higher. Most sections are also usable with Windows 95. EP-081 *$10.00*

Global Change in the Great Lakes

Ten scenarios (2-4 pp. each) and an introduction explain climate models and are packaged in a file folder. The scenarios describe the scientific community's prevailing interpretations of what may happen to the Great Lakes region in the face of global warming but are written in terms the general public can understand. The scenarios explore water resources, biological diversity, shipping, agriculture, airborne circulation of toxins, estuaries, eutrophication, recreation, fisheries, and forests. EP-078 *$6.00*

Great Lakes instructional material for the changing earth system. Provides integrative activities on global change to educators and decision-makers and must be purchased with EP-078 (above). Printing donated by Brunswick Marine. Cost includes EP-078 and additional postage charge. EP-080 *$9.00*

Summary of the global change scenarios (above) for the Great Lakes region. 2 pp. FS-057 *free*

Oceanic Education Activities for Great Lakes Schools (OEAGLS)

OEAGLS (pronounced "eagles") were developed from 1985 to 1991 for students in middle school grades. The ES-EAGLS (see above) are modifications of OEAGLS. Refer to that series description. Each OEAGLS title consists of a student workbook and a teacher guide.

Each title costs $3.00

Yellow Perch in Lake Erie EP-009
Shipping on the Great Lakes EP-013
Geography of The Great Lakes EP-014
Ohio Canals...EP-015
The Great Lakes Triangle..EP-017
Knowing the Ropes EP-018
We have Met the Enemy..EP-021
It's Everyone's Sea: Or is it? EP-022
A Great Lakes Vacation EP-024
Storm Surges EP-025

OEAGLets

Three activities provide students in primary grades with activities relevant to Lake Erie. The activities apply to all primary subject areas. *Each title costs $5.00*

Lake Erie - Take a Bow EP-031
Build a Fish to Scale EP-032
A Day in the Life of a Fish EP-033

Additional Educational Materials

Holling C. Holling's *Paddle-to-the-Sea* published by Houghton Mifflin Company. 28 pp. EP-076/B *$10.00*

Supplemental curriculum activities to accompany Holling C. Holling's Paddle-to-the-Sea. 168 pp. of activities for grades 3-6: science, social studies. EP-076 *$10.00*

The great Lake Erie. Sixteen experts present different facets of the importance of the Great Lakes to North America and the world. Written in 1987 and reprinted by Ohio Sea Grant in 1993. 148 pp. EP-079 *$10.00*

The Ohio Sea Grant Education Program: Development, Implementation, Evaluation. EP-075 *$8.00*

Abstracts of research in marine and aquatic education: 1975-1990. Brief review of the topics addressed in marine and aquatic education research, including knowledge and attitude testing of various groups, models of program evaluation, and comparisons of impact of education techniques. 24 pp. EP-077 *$2.00*

Costs cover publication, postage, and handling.

Make payment payable to The Ohio State University in U.S. dollars. Mail your request and payment to: Ohio Sea Grant Publications, The Ohio State University, 1314 Kinnear Road, Columbus, OH 43212-1194. ..ne 614/292-8949 or e-mail (cruickshank.3@osu.edu) if you have any questions or would like to place a large order.

Other ES-EAGLS

Great Lakes Climate and Water Movement

Water Movement

- How does water move in the Great Lakes basin?
- How long does it take water to flow through the Great Lakes?

Temperature and Climate

- What happens to heat energy reaching the Great Lakes?
- What causes the land-sea breeze?
- How do the Great Lakes affect temperature?
- How is weather influenced by the Great Lakes?

Lake Levels and Storms

What causes storm surges?

- How do storm surges affect water levels on Lake Erie?
- How do the levels of the Great Lakes change?
- What would be the result of regulating the level of one of the Great Lakes?

Seasons on the Great Lakes

- How do the Great Lakes change through the seasons?
- How does stratification affect water quality?
- What factors impact ice coverage on the Great Lakes?

Land & Water Interactions in the Great Lakes

Geography and Technology

- How well do you know the Great Lakes?
- What can GLIN tell us about land and water interactions?

History of Land and Water Interactions

- When did the rocks in the Great Lakes basin form?
- How were sedimentary rocks in the Great Lakes basin formed?
- How did rocks and rivers shape the Great Lakes?
- What evidence of glaciation exists in the Great Lakes region?
- What evidence of glaciation and geologic processes can be found on Great Lakes beaches?

Land and Water Interaction Today

- What causes the shoreline to erode?
- Can erosion be stopped?
- How fast can a shoreline change?
- How much land has been lost?
- What natural wonders of the Great Lakes relate to land and water interactions?
- How can a concept map represent land and ...eractions?

Life in the Great Lakes

Organisms in the Lakes

- How does a dichotomous key work?
- What are the characteristics of some Great Lakes fish?
- How do fish get their names?
- How are shorebirds adapted for feeding?
- What do scientists know about invader species of the Great Lakes?

Ecological Relationships

- Who can harvest a walleye?
- What does a biomass pyramid tell us?
- What is a food web?
- What factors affect the size of a natural population? (A Great Lakes fish example)
- How can a natural fish population be managed?

Estuary Values and Changes

- What is the role of plants in an estuary?
- How does the estuary serve as a nursery?

Great Lakes Environmental Issues

Resources and Reactions

- How big is a crowd?
- Who owns the resources of the Great Lakes?
- How (environmentally) insulting can we get?
- How skillfully can you read science articles?

Toxins in the Great Lakes?

- How much is one part per million?
- Which fish can we eat?
- How should the public heath be protected?
- How do toxins move through the food chain?
- How big is the problem of airborne toxins?
- Where do all the toxins go? (internal view)
- Where do all the toxins go? (external view)
- Could we live without chlorine in the Great Lakes?

Watershed and Basins Issues

- What can we learn about water quality in a river?
- What happens when nutrients enter a lake?
- What is the status of the Great Lakes Areas of Concern?

Oil Pollution

- Where does oil pollution come from?
- How can an oil spill be cleaned up?
- How does an oil spill affect living things?
- What if . . .? (a Great Lakes investigation)

Sea Grant
Ohio Sea Grant College Program

1314 Kinnear Road
Columbus, OH 43212-1194
614/292-8949
Fax 614/292-4364

http://www-ohiosg.osc.edu/OhioSeagrant

NOTICE

REPRODUCTION BASIS

- [x] This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

- [ ] This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").